PRODUCT ENGINEERING

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Editor

JULY, 1933

MCGRAW-HILL PUBLISHING CO., INC. VOLUME FOUR, NUMBER SEVEN

Industrial Control

EVERY one of us, no matter what his occupation, has watched the developments leading up to the final passage of the National Industrial Recovery Act with keen interest because of its potentially revolutionary effect on American industry and on our personal fortunes. Now that it is law we are faced with the task of adjusting ourselves to its requirements.

Since many of the readers of *Product Engineering* are connected with companies building industrial machinery and manufacturing equipment the effect of the new law on replacement of existing obsolete machinery and on introduction of new units is a vitally important matter. Word has come from Washington that machinery installations will be scrutinized carefully and that their necessity will have to be proved beyond a doubt, in view of their relation to employment of labor which is the primary object of the legislation. The immediate question that comes to mind is the extent to which industry will cooperate within itself and with the government.

A most encouraging development along this line is the following section in the letter accompanying the first code of practice to be submitted for administration approval, that of the Cotton Textile Institute:

"The cotton textile industry has taken account of the problem of . . . displacement of employees (by machinery) in formulating its proposed code . . . It has believed that the sound line of attack on this situation . . . is not to limit the development and use of improved mechanical devices and technic and materials, but to meet it by decreasing the hours of labor of the individual employee in the industry with accompanying adjustment in wages. . . .

"It is by such solutions, it is believed, that the community can continue to get the benefit of the American instinct for inventiveness and efficiency, with its great possibilities for further raising of the general standard of living, and yet avoid the hardship to the individual, which may otherwise arise in times like these."

If industry in general adopts this most progressive attitude, as we are convinced it will, the product engineer has nothing to fear but on the contrary is on the threshold of a new day in sane industrial mechanization.

The Cobbler and His Last

SCIENTIFIC discoveries, engineering developments and competition are forcing manufacturers into fields new to them. In some instances entirely new products are being developed. Other companies are refining their products by adopting new design principles. Photo-electric control, built-in motors, hydraulic operation, streamlining, welded construction, die-castings and new finishes are only a few of the items that are compelling attention.

Thus it is that many engineers in an executive capacity are faced today with problems that involve fundamental principles entirely new to them. What should be their method of procedure? Professional "pride" may impel the engineer to scorn the assistance of those who know. But engineering mistakes that result from conceit are often built into monuments that endure to mock. For any engineer to assume authoritative knowledge he does not possess is professional suicide.

There is no dearth of available men who are experts in specialized fields. Such men can be added to the engineering staff to solve the problems that require their special talents. And their findings and recommendations should be respected. In addition to specialized knowledge within the department, the executive engineer should seek and heed the recommendations of reputable companies that furnish materials and parts.

Honest mistakes are to be expected and forgiven, but those born of conceit deserve only condemnation. "Let the cobbler stick to his last."

Engineering Standards for the Design of Springs

Together with the tables on pages 279 and 280, this article gives all the formulas, data and specifications required for the design of helical springs for tension, compression and torsion. Tables of commercial tolerances and samples of standard drawings are included

W. M. GRIFFITH, *Executive Engineer, Atlas Imperial Diesel Engine Company*

DURING the past few years a large number of firms have devised or adopted standards covering practically every phase of engineering and industrial activity. Economy, of course, is the basic reason behind this development, and there can be no doubt that in practically every industry properly prepared standards materially lessen the cost of production. As would be expected, the results and benefits are in direct proportion to the amount of care and effort put into the work of establishing the standards.

One of the objects of standardization is to secure proper control of the product from its design through to its completion and disposal or sale. An example of standards devised for this purpose are those in force at the Atlas Imperial Diesel Engine Company for the design of springs, the standards specifying materials, sizes, finishes, formulas, stresses, and classes of service, completely standardizing the whole procedure in the design of springs, including the drawings. In fact, the specifications put the problem of success or failure directly up to the spring manufacturer, as every factor over which the purchaser and user of springs has control is covered. The use of these standards over a period of nearly three years has produced results which have been most gratifying. Spring failures have been eliminated almost entirely, and in every case where failure did occur it has been caused by conditions beyond the control of the designer and purchaser of the springs.

General Instructions

When designing a part or mechanism which incorporates a spring, it is of the utmost importance that the dimensions of the spring be determined early in the design, in order that the limitations specified by the standards will not be exceeded. When this rule is followed strictly, no difficulty is encountered in designing

a spring tbat is moderately stressed and properly proportioned.

It should be borne in mind that springs can be made to close dimensional and load tolerances only at considerable extra cost. Table 1 gives the permissible manufacturing tolerances which the average spring manufacturer can easily maintain at no increase in cost, and every effort should be made to design the part or mechanism in such a manner that a spring with these variations can be used.

Materials, Sizes and Finish

In general, springs are made of music wire, vanadium steel, carbon steel or phosphor bronze round wire. Brass, Monel metal or sections other than circular are used only when, for some special reason, it is obviously impossible or undesirable to use one of the above materials. Referring to the table of classification of springs according to service, as given on p. 280, steel springs for Class 1 service are made of either vanadium steel or music wire. Non-ferrous springs for Class 1 service are always made of phosphor bronze.

For music wire springs, S.A.E. 1095 is specified. S.A.E. 6150 is specified for vanadium steel and S.A.E. 1360 for carbon steel. These last two materials are used in Washburn & Moen gage sizes from 7-0 to 12, and in square or rectangular sections from a minimum size of $\frac{1}{32} \times \frac{1}{32}$ in. to a maximum of $\frac{1}{2} \times \frac{1}{2}$ in., advancing by thirty-seconds of an inch. Springs made of music wire are not finished, while other steels are ordinarily given a black japan finish. Steel springs that are used under conditions where they are liable to rust are cadmium-plated by the spring manufacturer.

For phosphor bronze springs, S.A.E. 81 is specified; for brass, S.A.E. 80. Monel metal is specified as such. Phosphor bronze is used only for small springs when it appears from the design that it is the proper material for the service or when the springs must be rust-proof. Brass, phosphor bronze and Monel metal are drawn to Brown & Sharpe gage sizes. Springs made of these non-ferrous materials ordinarily are not finished in any manner.

Formulas, Stresses and Classes of Service

For helical compression and extension springs, other conditions being equal, the carrying capacity varies as the cube of the diameter of the wire, inversely as the mean diameter of the coil, and directly as the stress. The deflection varies directly as the load and directly as the number of active coils, directly as the cube of the mean diameter of the coil, and inversely as the fourth power of the wire diameter. These relations are not true, of course, for extension springs wound with initial tension.

The best proportioned helical compression or extension spring has a spring index—ratio of outside diameter of coil to diameter of wire—of about 9. Designers should approach this value as closely as possible. In designs having smaller values of spring index the actual stress in the spring is greater than that given by the spring formulas. As shown in Fig. 1, the stress factor increases rapidly as the spring index falls below 5. Consequently, springs with an index less than 5 are not used.

Values for the torsional modulus of elasticity and maximum permissible stress for springs in various classes of service are given in the tables on p. 280. The permissible working stresses, as given in those tables, may appear to be extremely conservative, but experience has proved that springs designed with higher working stresses are usually a source of constant trouble. In this connection, care must be exercised in determining which of the three classes of service conditions apply to the spring being designed. In case of doubt the lower stress values should be used. Also, when

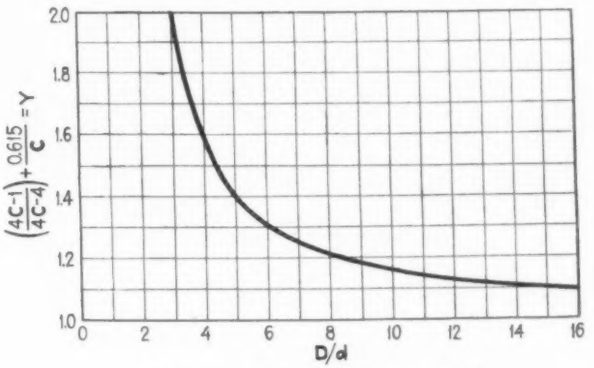


Fig. 1—Stress factor, as obtained from the Wahl formula, by which the calculated theoretical stress is multiplied to obtain the actual stress in a helical spring

TABLE I
PERMISSIBLE MANUFACTURING VARIATIONS FOR HELICAL SPRINGS

Outside Diameter	Variation +or−	Length	Variation +or−	Pitch	Variation +or−
Smaller than $\frac{1}{8}$	0.003	Less than 1	$\frac{1}{32}$	4 coils or less	$\frac{1}{4}$ coil
$\frac{1}{8}$ to $\frac{1}{4}$	0.005	1 to 2	$\frac{1}{16}$		
		2 to 3	$\frac{3}{32}$	4 to 8 coils	$\frac{1}{2}$ coil
$\frac{1}{4}$ to $\frac{1}{2}$	0.008	3 to 5	$\frac{1}{8}$		
$\frac{1}{2}$ to 1	0.015	5 to 8	$\frac{5}{32}$	8 to 15 coils	$\frac{3}{4}$ coil
		8 to 12	$\frac{1}{4}$		
1 to 2	$\frac{1}{32}$	12 to 18	$\frac{3}{8}$	15 to 25 coils	1 coil
2 to 3	$\frac{1}{16}$	18 to 24	$\frac{1}{2}$		
		24 to 30	$\frac{3}{4}$	Over 25 coils	2 coils
Over 3	$\frac{3}{32}$	Over 30	1		

Permissible load variation plus or minus 10 per cent

steel springs are to be subjected to temperatures above normal, the value of the torsional modulus of elasticity used in the calculations must be the modulus at the temperature to which the spring will be subjected. The value can be obtained from the curve given in Fig. 2.

When the deflection cycles are rapid and regular, as in Class 1 service, the springs must be designed so that their natural frequency is of sufficient magnitude to escape resonance with any harmonic below the 20th order. In the following equation d is the diameter of the wire, D is the outside diameter of the coil, N is the number of active turns, G is the modulus of elasticity in torsion, and H is the order of the harmonic.

$$\frac{250\ \dfrac{d \times \sqrt{G}}{(D-d)^2 \times N}}{\text{Deflection cycles per min.}} = H \text{ (20 minimum)}$$

The right-hand member of this equation gives the order of the harmonic, and its value should be as much above 20 as possible.

Helical Compression Springs

Compression springs are designed in accordance with the accompanying formulas. These formulas are arranged in the order in which they usually are used when making spring calculations, and are based on $1\frac{1}{4}$ dead coils at each end of the spring. Less than this number of dead turns should not be used. The minimum and maximum diameter, inside or outside, is determined by the designer and fixed so as to clear all adjacent parts when the spring is compressed to its minimum working length.

The "minimum working length" is the minimum to which a spring can be compressed in actual operation without danger of the coils clashing. To determine this minimum, tests were conducted by the Atlas Imperial Diesel Engine Company on a large number of springs of all sizes and types. These experiments disclosed that to insure freedom from clash, the amount of space between coils when the spring is compressed to the minimum working length, should not be less than 10 per cent of the wire diameter.

The formulas given here for the number of effective turns provide for this amount of minimum clearance. A larger clearance would, of course, decrease the number of turns in the spring, which in turn would, for a given spring deflection, increase the working stress. Another advantage of using the minimum clearance is that springs with such small space between turns will upon examination show coil clash if there is any dangerous spring surge. All springs designed by the Atlas Imperial Diesel Engine Company provide for this amount of clearance and of all the springs so designed, none has shown the slightest indication of the coils clashing or even touching, indicating that a clearance space equal to 10 per cent of the wire diameter is sufficient.

With reference to the other mechanical features of

COMPRESSION SPRING FORMULAS

Spring index, $\frac{D}{d}$ or $\frac{D}{b}$ = 5 (Minimum)

Round	Square	Rectangular
$W = \frac{0.3927\,S\,d^3}{D-d}$	$W = \frac{0.444\,S\,d^3}{D-d}$	$W = \frac{S\,b\,t\sqrt{b^2+t^2}}{3.185(D-b)}$
$N = \frac{l-(2.25\,d)}{1.10\,d}$ (Max)	$N = \frac{l-\left[d\left(\frac{D}{D-d}+1\right)\right]}{0.53\,d\left(\frac{D}{D-d}+1\right)}$ (Max.)	$N = \frac{l-\left[t\left(\frac{D}{D-d}+1\right)\right]}{0.53\,t\left(\frac{D}{D-d}+1\right)}$ (Max.)
$F = \frac{8\,P\,(D-d)^3}{G\,d^4}$	$F = \frac{5.58\,P\,(D-d)^3}{G\,d^4}$	$F = \frac{11.16\,P\,(D-b)^3}{G\,b\,t\,(b^2+t^2)}$
$F_N = F\,N$	$F_N = F\,N$	$F_N = F\,N$
$L = F_N + l$	$L = F_N + l$	$L = F_N + l$
Pitch $= \frac{L-(2.25\,d)}{N}$	Pitch $= \frac{L-\left[d\left(\frac{D}{D-d}+1\right)\right]}{N}$	Pitch $= \frac{L-\left[t\left(\frac{D}{D-d}+1\right)\right]}{N}$
Load per inch of deflection $= \frac{P}{F_N}$	Load per inch of deflection $= \frac{P}{F_N}$	Load per inch of deflection $= \frac{P}{F_N}$
Solid length $= (N+2.25)\,d$	Solid length $= \left[0.48\,d\left(\frac{D}{D-d}+1\right)N\right] + \left[d\left(\frac{D}{D-d}+1\right)\right]$	Solid length $= \left[0.48\,t\left(\frac{D}{D-d}+1\right)N\right] + \left[t\left(\frac{D}{D-d}+1\right)\right]$
$l = (1.10\,d\,N) + (2.25\,d)$	$l = \left[0.53\,d\left(\frac{D}{D-d}+1\right)N\right] + \left[d\left(\frac{D}{D-d}+1\right)\right]$	$l = \left[0.53\,t\left(\frac{D}{D-d}+1\right)N\right] + \left[t\left(\frac{D}{D-d}+1\right)\right]$

EXTENSION SPRING FORMULAS

Spring index, $\frac{D}{d}$ = 5 (Minimum)

$F_N = F\,N$ Pitch $= \frac{L}{N}$ Load per in. of deflection $= \frac{P}{F_N}$

Round	Square	Rectangular
$W = \frac{0.3927\,S\,d^3}{D-d}$	$W = \frac{0.444\,S\,d^3}{D-d}$	$W = \frac{S\,b\,t\sqrt{b^2+t^2}}{3.185(D-b)}$
$N = \frac{L}{d}$ (Max.)	$N = \frac{L}{0.48\,d\left(\frac{D}{D-d}+1\right)}$	$N = \frac{L}{0.48\,t\left(\frac{D}{D-b}+1\right)}$
$F = \frac{8\,P\,(D-d)^3}{G\,d^4}$	$F = \frac{5.58\,P\,(D-d)^3}{G\,d^4}$	$F = \frac{11.16\,P\,(D-b)^3}{G\,b\,t\,(b^2+t^2)}$

D = Outside diameter, inches
b = Width of material, inches
d = Diameter of material, inches
W = Carrying capacity, pounds
S = Stress, lb. per sq. in.
t = Thickness of material, (parallel with axis), inches
N = Number of effective turns
l = Minimum working length, inches
F = Deflection of 1-turn, inches
F_N = Total deflection, inches
P = Load, pounds
L = Free length, inches
G = Torsional modulus of elasticity

TORSION SPRING FORMULAS

Spring index, $\frac{D}{d}$ = 5 (Minimum) Pitch $= \frac{L}{N}$

Round	Square or Rectangular
$W = \frac{0.098\,S\,d^3}{R}$	$W = \frac{0.166\,S\,t\,b^2}{R}$
$F_N = \frac{20\,P\,l\,R^2}{E\,d^4}$	$F_N = \frac{12\,P\,l\,R^2}{E\,b^3\,t}$
$N = \frac{L}{d}$ (Max.)	$N = \frac{L}{0.48\,t\left(\frac{D}{D-b}+1\right)}$ (Max.)

b = Width of material, inches
d = Diameter of material inches
t = Thickness of material (parallel with axis), inches
l = Length of rod (effective spring length, uncoiled), inches
W = Carrying capacity, pounds
S = Stress, lb per sq. in.
N = Number of effective turns
F_N = Deflection at point of application of load, inches
P = Load, pounds
L = Free length, inches
R = Length of arm, inches
E = Modulus of elasticity

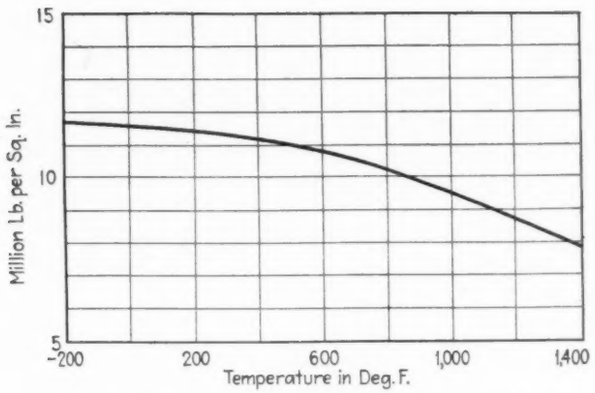
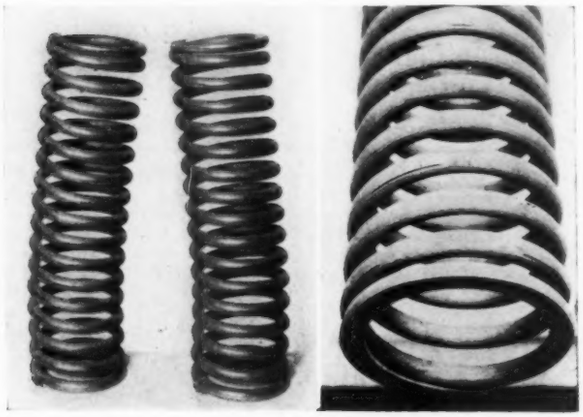
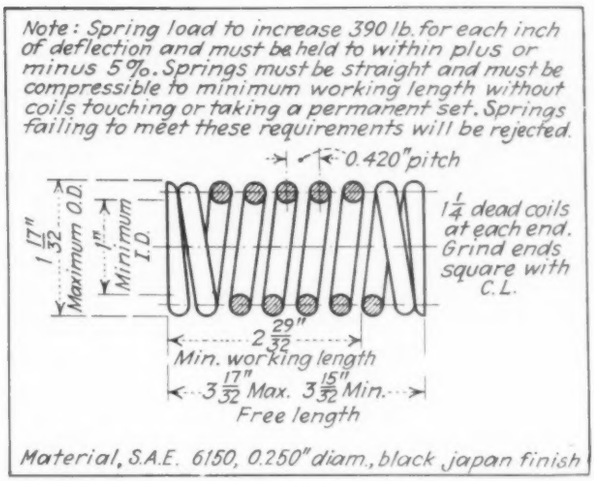


Fig. 2—For other than normal temperatures, the torsional modulus of elasticity for steel should be selected from the above curve

Fig. 3—To the left are shown two crooked springs that slipped past the inspection department. To the right—defective material as made evident by etching the spring in a boiling solution of 50 per cent hydrochloric acid




Note: Spring load to increase 390 lb. for each inch of deflection and must be held to within plus or minus 5%. Springs must be straight and must be compressible to minimum working length without coils touching or taking a permanent set. Springs failing to meet these requirements will be rejected.
0.420" pitch
1 17/32" Maximum O.D.
1" Minimum I.D.
1 1/4 dead coils at each end. Grind ends square with C.L.
2 29/32" Min. working length
3 17/32" Max. 3 15/32" Min. Free length
Material, S.A.E. 6150, 0.250" diam., black japan finish

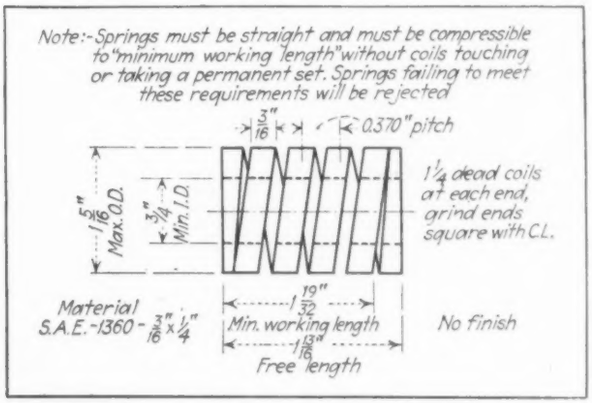

Note:-Springs must be straight and must be compressible to "minimum working length" without coils touching or taking a permanent set. Springs failing to meet these requirements will be rejected
3/16"
0.370" pitch
1 5/16" Max. O.D.
3/4" Min. I.D.
1 1/4 dead coils at each end, grind ends square with C.L.
Material S.A.E.-1360 - 3/16" x 1/4"
1 19/32" Min. working length
1 13/16" Free length
No finish

Fig. 4—Examples of standard drawings of compression springs made out of round and rectangular wire

the design, compression springs should have the ends ground square with the center line of the coil. In addition, the springs should be guided at each end, either on the outside or the inside, or both outside and inside. Where springs are to operate inside one another, one spring is wound right hand and the other left hand.

Helical Extension Springs

Extension springs are designed in accordance with the accompanying formulas. Such springs may be close wound, with or without initial tension, or they may be open wound coils. When the load is important, they are always wound without initial tension. The dimensions of extension springs are made to clear all adjacent parts when the spring is extended to its maximum working length.

Helical Torsion Springs

Torsion springs are always designed to operate in the direction which causes the spring to close. They may be close or open wound and the dimensions are limited so as to clear all adjacent parts when the spring is in its maximum and minimum working positions. The design calculations are made according to the accompanying formulas.

Drawing Specifications

In order to obtain simplicity and uniformity, all drawings of springs are made on 8½x11-in. sheets. The drawings need not necessarily be made completely to scale. The wire size is specified in decimals of an inch for round material. No gage numbers are used. Square or rectangular material is specified in fractions of an inch. For rectangular material, in order to indicate whether the material is edge-wound or flat-wound the thickness is shown opposite a spring coil in addition to which the size is specified at the bottom of the sheet. The finish, if any is required, and the material to be used are also shown on the drawing. In dimensioning the drawings, the tolerances as given in Table 1 are used, if possible. If closer tolerances are necessary, the dimensions of the spring must be such as to properly provide for them. The largest possible tolerance is always specified.

Compression Spring Drawings

Examples of standard drawings of compression springs are shown in Fig. 4. The notations, together with the dimensions, give all the specifications. Only

Music Wire Sizes

(Roebling Gage)

No.	Decimal	d^2	d^3	d^4
00	0.0085	0.000072	0.000000614	0.00000000522
0	0.009	0.000081	0.000000729	0.00000000656
1	0.010	0.000100	0.000001000	0.00000001000
2	0.011	0.000121	0.000001331	0.00000001464
3	0.012	0.000144	0.000001728	0.00000002074
4	0.013	0.000169	0.000002197	0.00000002856
5	0.014	0.000196	0.000002744	0.00000003842
6	0.016	0.000256	0.00000410	0.0000000655
7	0.018	0.000324	0.00000583	0.0000001050
8	0.020	0.000400	0.00000800	0.0000001600
9	0.022	0.000484	0.00001065	0.0000002343
10	0.024	0.000576	0.00001382	0.0000003318
11	0.026	0.000676	0.00001758	0.000000457
12	0.028	0.000784	0.00002195	0.000000615
13	0.030	0.000900	0.00002700	0.000000810
14	0.032	0.001024	0.00003277	0.000001049
15	0.034	0.001156	0.00003930	0.000001336
16	0.036	0.001296	0.0000467	0.000001680
17	0.038	0.001444	0.0000549	0.000002085
18	0.040	0.001600	0.0000640	0.000002560
19	0.042	0.001764	0.0000741	0.000003112
20	0.044	0.001936	0.0000852	0.000003748
21	0.046	0.002116	0.0000973	0.00000448
22	0.048	0.002304	0.0001106	0.00000531
23	0.051	0.002601	0.0001326	0.00000676
24	0.055	0.003025	0.0001664	0.00000915
25	0.059	0.003481	0.0002054	0.00001212
26	0.063	0.003969	0.0002500	0.00001575
27	0.067	0.00449	0.0003008	0.00002015
28	0.071	0.00504	0.0003579	0.00002541
29	0.074	0.00548	0.000405	0.00002999
30	0.078	0.00608	0.000475	0.00003701
31	0.082	0.00672	0.000551	0.0000452
32	0.086	0.00740	0.000636	0.0000547
33	0.090	0.00810	0.000729	0.0000656
34	0.095	0.00903	0.000857	0.0000814
35	0.100	0.01000	0.001000	0.0001000

when the load tolerance must be closer than 10 per cent is the notation preceded by: *"Spring load to increase — lb. for each — in. of deflection, and must be held to within plus or minus 5 per cent."* Compression spring dimensions include only the pitch, minimum working length, free length, and maximum outside and minimum inside diameters.

Extension Spring Drawings

Extension spring drawings are made as in Fig. 5 and carry the notations shown. Only when the load tolerance must be closer than 10 per cent is the notation preceded by the statement: *"Spring load to increase — lb. for each — in. of deflection and must be held to within plus or minus 5 per cent."* The drawing must indicate if the spring is close wound or open wound. If close wound, the statement indicates the amount of initial tension; if open wound, the pitch is specified. Extension spring dimensions include the free length from the center of the first active coil to the center of the last active coil, the maximum working length, the length between ends, and the maximum outside and minimum inside diameters. Also, complete details of the ends are given, showing one or both end views if necessary.

Helical Torsion Spring Drawings

Torsion springs follow the form reproduced in Fig. 6, and carry the notations as indicated. When the load tolerance is closer than 10 per cent, the notation is preceded by: *"Spring load at maximum deflection position to be—in.lb. (or ft.lb.) and must be held to within plus or minus 5 per cent."* The drawings for torsion springs indicate not only the maximum deflection, but also its direction, and state whether the spring is wound right or left hand and if close or open wound. Dimensions include the free length of the active coils, and the maximum outside and minimum inside diameters and the pitch, if open wound. In addition, complete details of the ends are given showing both end views if necessary.

Inspection

In setting up standards of quality and performance, it is insufficient to merely specify the required degree of excellence. The authority to issue specifications carries with it the responsibility of seeing to it that they are followed out. Therefore, in issuing standards of the type described here, it is the duty of the Engineering Department to educate the Inspection Department to strict observance of all details. In addition to checking all springs for drawing specifications, the inspectors should be required to examine the coils for roller scores, check the minimum working length and solid length, as well as the squareness of the ends, the hardness of the wire and the uniformity of pitch.

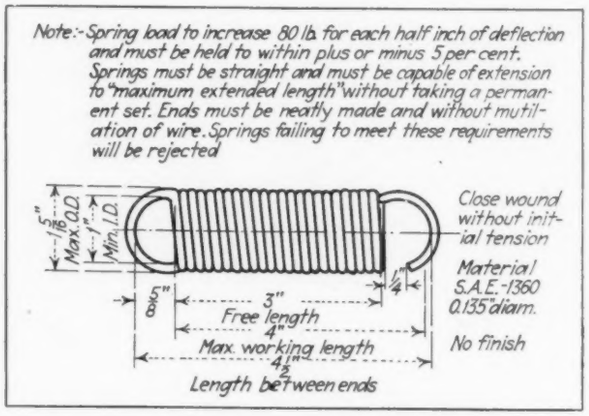
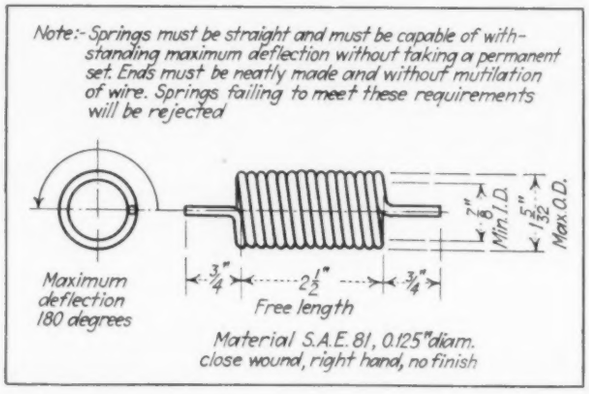

Note:- Spring load to increase 80 lb. for each half inch of deflection and must be held to within plus or minus 5 per cent. Springs must be straight and must be capable of extension to "maximum extended length" without taking a permanent set. Ends must be neatly made and without mutilation of wire. Springs failing to meet these requirements will be rejected
5/16" Max. O.D.
1" Min. I.D.
Close wound without initial tension
Material S.A.E.-1360 0.135" diam.
No finish
5/8"
3" Free length
1/4"
4" Max. working length
4 1/2" Length between ends

Fig. 5—Standard drawing for an extension spring. The original drawings are made on an 8½x11-in. sheet

Fig. 6—Standard drawing of a helically wound torsion spring


Note:- Springs must be straight and must be capable of withstanding maximum deflection without taking a permanent set. Ends must be neatly made and without mutilation of wire. Springs failing to meet these requirements will be rejected
7/8" Min. I.D.
15/32" Max. O.D.
Maximum deflection 180 degrees
3/4"
2 1/2" Free length
3/4"
Material S.A.E. 81, 0.125" diam. close wound, right hand, no finish

PRODUCT DEVELOPMENTS

What the designing engineer will find of special interest from among the many varied exhibits at the Century of Progress—New style portable humidifiers that fit the home —Milk pasteurizer with full-automatic temperature control

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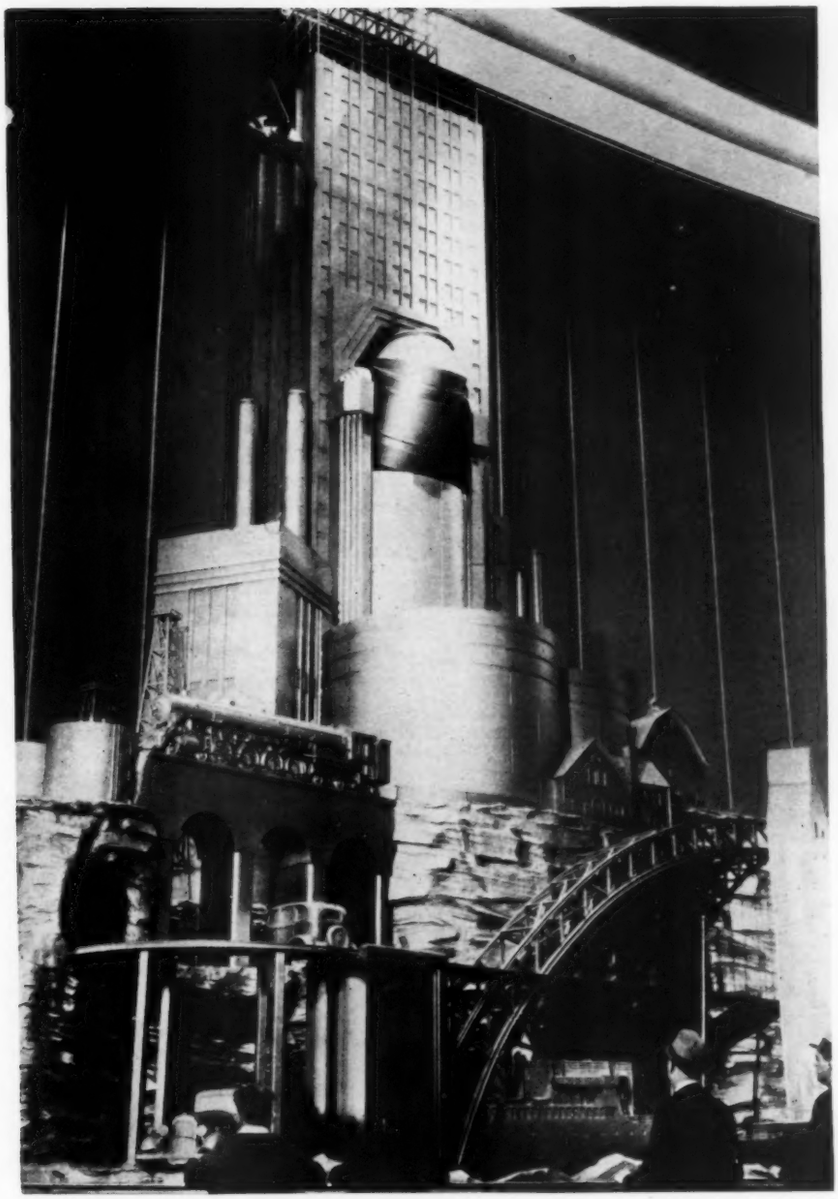

Mass sculpture that dominates U.S. Steel exhibit at Chicago depicts some of the many products made of steel

▸ A Century of Progress

Chicago calls its current world's fair "A Century of Progress," and has built it around the advancement of science in that period, and on the applications of science today. Such being the case, the exposition is naturally a paradise for product engineers, because the great majority of the exhibits, outside of some of the pure science demonstrations, are engineered products of one sort or another. Three or more days at the fair will surely give any product engineer enough inspiration and sufficient ideas to keep him going for months.

A study of the evolution of any product, device or mechanism is instructive. The Chicago show is full of clever portrayals of such evolutions. And some of them go pretty far back. For instance, in the space of the Italian government in the Hall of Science there is a reproduction of a ball thrust bearing discovered in the wreck of the emperor's barge uncovered by the drainage of Lake Nemi. The bearing is supposed to have supported a heavy statue which was required to revolve on its base. The retainer is of wood and the balls are of bronze with integral spindles that are retained by bronze straps. The balls are approximately an inch in diameter and the retainer three or four feet across. Beside it is a modern two-inch thrust bearing that carries about the same load.

One who is interested in mathematics will enjoy the models of warped surfaces and the demonstrations of mechanical means of checking mathematical theory. Also the many working models in the physics division, and the lectures and demonstrations put on by Union Carbide & Carbon on liquid air; by

The Burlington's earliest and and latest locomotives typify progress in Western motive power

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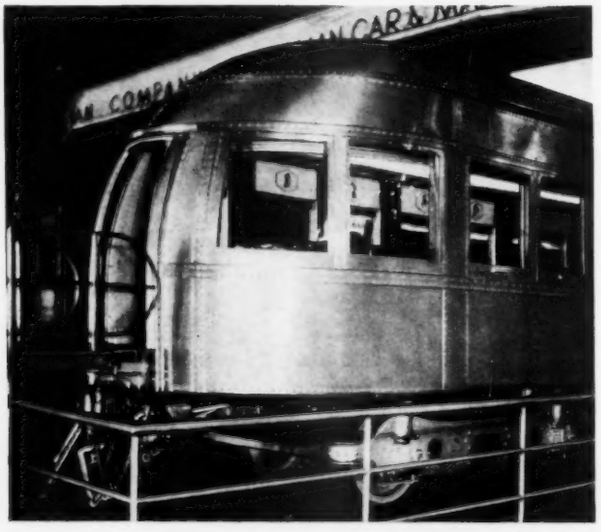

Rear end of one of the all-aluminum Pullmans displayed at the fair. The natural aluminum is finished by Simonizing

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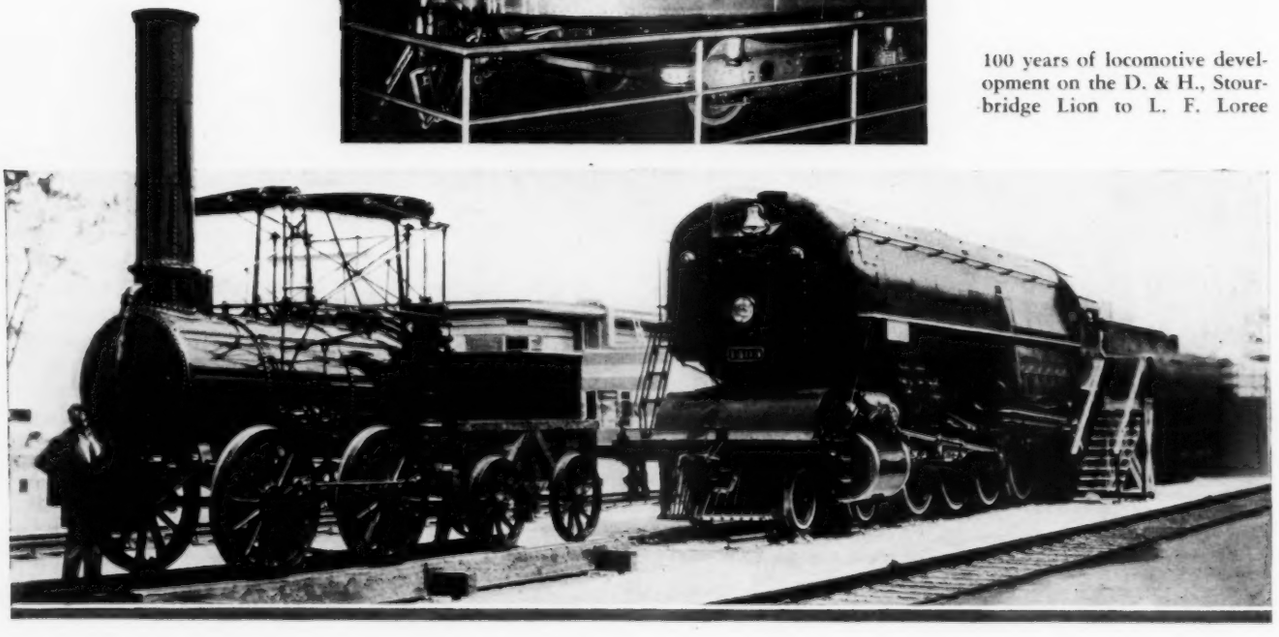


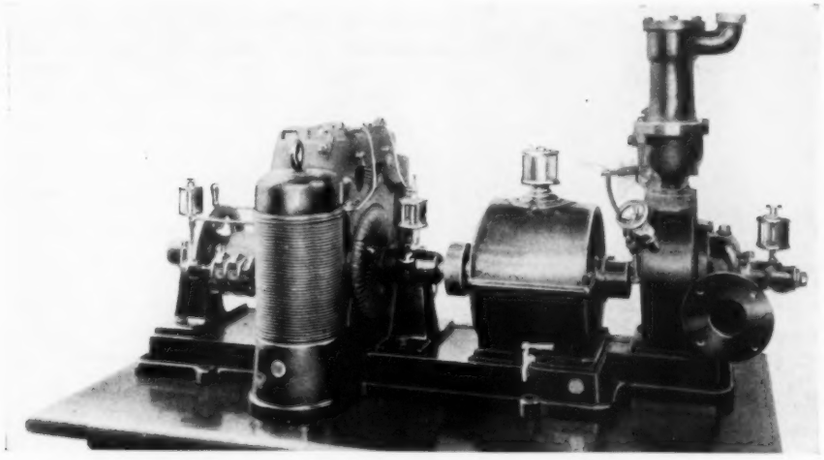
100 years of locomotive development on the D. & H., Stourbridge Lion to L. F. Loree

General Electric in its "House of Magic," where sound is made visible, light audible, and the stroboscope is put through its paces; in the General Motors Building, where the research laboratories are demonstrating crankshaft balancing, solid fuel injection, fuel metering, the solution of carbon in alloy steels as the temperature varies, and the tenacity of an oil film; at the Westinghouse space, where all sorts of electrical phenomena can be experimented with on apparatus that was designed solely for that purpose; and the Bureau of Standards exhibits, where there is a wind tunnel, a spectroscope, a weatherometer, and strains in glass under polarized light.

If machinery is his primary interest he can find plenty of it in motion. In the General Exhibits Building he can see in operation the machines used in making shirts. Across the way a full-fashioned hosiery machine is at work. Nearby Ipana toothpaste tubes are being made and filled on machinery that duplicates that of the home plant.

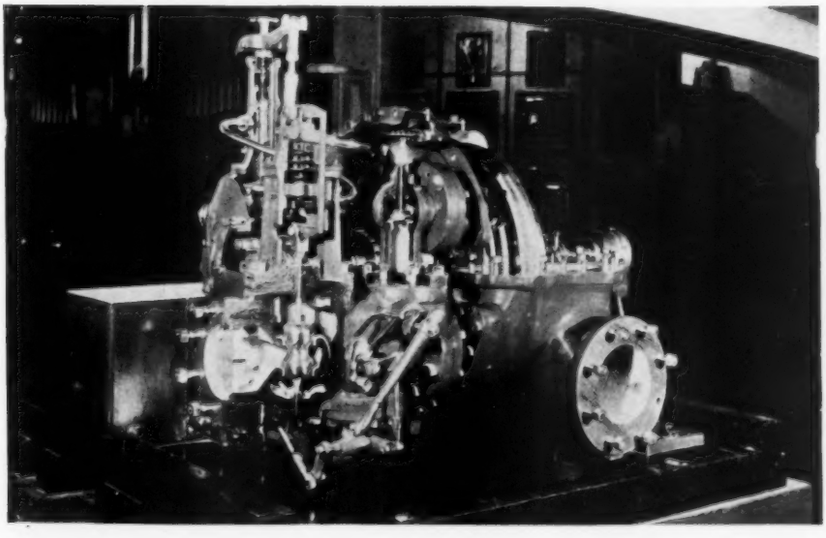
Business machines from the earliest to the latest are displayed in the same building. A model of the Gutenberg printing press can be compared with a modern press. Mechanical drives are shown at the Link-Belt booth in the next pavilion, and mechanical motions at the Borg-Warner space in the Transportation Building.

Materials are given plenty of space. U. S. Steel shows case after case of products made of stainless steel. The Copper & Brass Research Institute display contains applications of these materials to industrial, architectural and domestic uses. Union Carbide & Carbon has some beautiful etched panels of stainless steel and glass. More than a score of manufacturers have joined in an exhibit showing products finished in porcelain enamel. All sorts of new materials or material applications will be found in the model homes, which are variously built of wood, brick, steel, glass and synthetic materials. The furnishings in these houses, and the model house set up by the electrical industry in the Electric Building, are also worthy of study. Other domestic machinery is on display in the Home-Planning Building.



DeLaval is showing the first commercial steam turbine generating unit to be operated in America

General Electric is attracting many visitors by its sectioned model of a modern generating unit



When it comes to transportation equipment there are plenty of opportunities to trace evolution. On the outdoor tracks, side by side, are the Stourbridge Lion model, first locomotive engine to run on tracks in America, and the L. F. Loree, latest freight engine built for the Delaware & Hudson; the Royal Scot, Britain's crack train, and a section of the B. & O.'s Capitol Limited; the newest Burlington passenger locomotive and rolling stock, and their ancestors of fifty years ago.

In the huge rotunda of the Transportation Building the march of progress is well portrayed, from Rocky Mountain stage coach and Conestoga wagon to aluminum Pullman and twin-motored air transport plane. Also included are ancient and modern fire apparatus and farm tractors, one of the Navy's helium cylinder cars, a modern bus, Miss America IX and a series of outboard motors.

Interesting and informative lubrication exhibits are to be found in the adjacent building, and a modern high-speed escalator. Also a series of testing machines used in the construction of precision ball bearings, and at the other extreme a St. Paul electric locomotive.

Color comes into its own at this exposition. Here again the harmony of the whole is the important consideration. Joseph Urban has taken a palette of twenty-two colors, including black, white, silver and gold, and has produced something hitherto unapproached. But the observer must stand off to get the whole effect before he passes judgment. There has probably never been so good a demonstration of the

importance of designing a building, or any other product, with a full realization of the effect of its surroundings. The substitution of color for ornamentation has of course led to considerable economies in construction cost.

▸ Portable Humidifier

All sorts of humidifiers have been devised in an endeavor to moisten the aridity of the average American home in winter. The latest Westinghouse contribution to this development is the portable unit illustrated, which holds 3¼ gal. of water, enough to last 14 hr. at 72 deg. F. and 25 per cent relative humidity.

It consists mechanically of a rotating mechanical atomizer, a rotating tube for elevating water from the bottom reservoir to the atomizer, and a fan for circulating the moistened air. The single assembly formed by these units is suspended on the shaft of a small vertical motor, and mounted on stainless steel springs. The housing is artistically designed and finished in anodically treated aluminum. Current consumption is 40 watts, and the motor is free of radio interference.

The fan has four blades and operates with extreme quietness. Water raised by the rotating tube is 100 times what is needed for atomization, the excess washing the incoming air and dropping to the reservoir, where impurities are separated out.

No mist of water is discharged into the room. Evaporation is done inside the humidifier, and varies with the dryness of the room air.

Aluminum beer barrel—21 lb., boy—55 lb. Barrel holds 15½ gal., is 22 in. long, 17 in. diam. It is claimed that the aluminum does not affect color or taste of beer

▸ Automatic Temperature Control on Pasteurizers

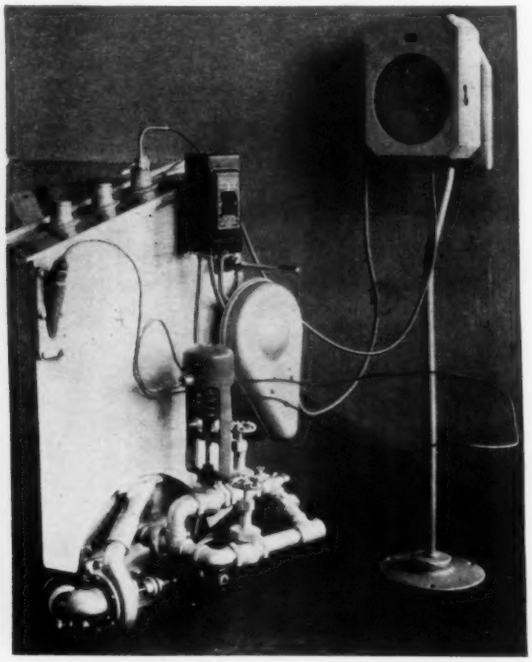
One of the most recent developments of the Cherry-Burrell Corp. is an all-welded chrome-nickel steel 12,000-gal. spray pasteurizer for milk. The new feature of this design is the complete automatic regulation of the temperature.

By means of a thermostatic valve which controls the steam supplied for the heating water, the temperature of this water is kept at a predetermined figure. The heating water is circulated through the coils in the tank by means of a motor-driven centrifugal pump. Another thermostat controls the temperature of the milk. When the milk has reached the pasteurizing temperature, the thermostat automatically shuts off the motor driving the circulating pump and also cuts off the steam supplied to the heating water.

With this dual automatic control the rate at which the milk is heated can be set at any predetermined figure and maintained at this figure.

Portable motor-driven humidifier

Welded stainless milk pasteurizer



Graphical Analysis of Cam Roller Mountings

A simple graphical method for analyzing roller mountings to obtain the best conditions relative to the thrust loads

E. CHAT SHANKS

ON CAM mechanisms, the roller and its mounting have a direct bearing upon both the power consumption and the smoothness of operation. But too often the cam roller mounting receives little consideration during the preliminary stages of the design with the result that it is located in whatever space is available after the remainder of the design has been developed. The mounting of the roller is then restricted by space limitations and movements which must be imparted, thereby making it sometimes necessary to resort to an inferior arrangement.

Factors that govern the location of the roller and movement with respect to the center of the cam are: direction of rotation, direction of the load, and the load conditions to be met. Although the various forces can all be solved mathematically, such a procedure would embrace considerable detail. A simpler method of arriving at the best roller mounting is by an analysis of layouts of the mechanism.

The direct thrust at any point on a cam contour lies in a perpendicular to the tangent at that point. If the contour is composed of a series of consecutive arcs, the perpendicular is the radial line through the point. The magnitude of the thrust can be indicated by laying it off to scale on the radial line.

The roller movement is perpendicular to the line through the roller center and the fulcrum of a swinging mounting, or is parallel to the slide of a sliding mounting. On the swinging type the instantaneous directions change because of the angularity of the roller arm; on the sliding type the direction is constant.

Referring to the resolution diagram, Fig. 1, showing both types of mounting: A is a point on the contour below which is the roller arm fulcrum. The sliding mounting is assumed to be parallel to and coincident with the horizontal center line through O, the center of cam rotation. P is an arbitrary point, and Q is the center of the contour arc. AR is the line of imparted motion, instantaneous for the swinging mounting. The rotation is such that the movement is from O, the direction of cam thrust P is from A toward P, and the movement is from A toward R.

If P and R coincide, the arrows are directly opposed and the magnitudes of the two forces are equal. This seldom occurs because the angle θ between line AP and AR usually subtends a component PR. The component is parallel to the centerline of the arm, or perpendicular to the centerline of the slide. Its magnitude, PR increases the resultant applied thrust AP by an amount SP which increases the bearing and deflection loads. The detrimental component is proportional to the tangent of angle θ:

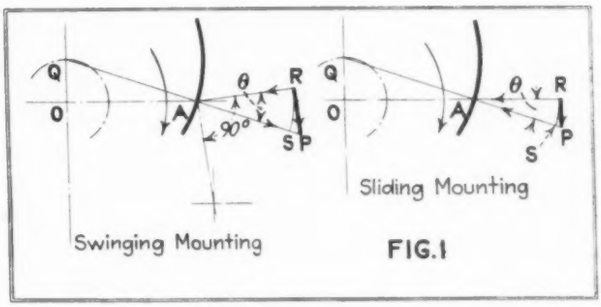


Fig. 1—In the resolution diagram for the two types of roller cam mountings, the detrimental components RP are proportional to the angle θ

$$\frac{\text{Detrimental Component}}{\text{Load Component}} = \tan\theta = PR/AR$$

Neglecting other losses, the ratio of the applied force to the effective force is the secant of angle θ:

$$\frac{\text{Applied Power}}{\text{Effective Power}} = \sec\theta = AP/AR = AP/AS$$

Since the secant extends from one to infinity, it follow that if angle θ is 0 deg., no power is lost in the mounting; if angle θ is 90 deg., the entire power available is wasted. At intermediate points the ratio of waste to effective power is the secant of angle θ minue 1:

$$\frac{\text{Wasted Power}}{\text{Effective Power}} = \sec\theta - 1 = SP/AS$$

Since the relative efficiency is dependent upon angle θ, a visual comparison of the angles will reveal the merits of different layouts.

Dwell portions of the contour can be analyzed in the

same manner as the nodes, but the fact that Q becomes coincident with O must be considered. Then the thrust is in a radial line from O. Caution is required at the point where the dwell and node join, for the direction of rotation must be considered. If the roller is passing from node to dwell, the cam thrust is along the line AO; in passing from dwell to node, it lies in line AQ of the diagram. This is especially important on cams without accelerated and decelerated motions, that involve appreciable impact.

The ideal design is coincidence of the lines AP and AR, producing a direct thrust of the cam in the direction of roller movement. Like most ideals, this is never realized for a total cam cycle, but may be approached by careful analysis and design.

Most machine loads tend to increase or decrease under motion. A load may be greater at the start, due to inertia, and decrease as soon as full velocity is reached. Another may increase because of work in process. The load may be stopped easily at the end of the movement on account of friction and tool pressures, or it may tend to keep in motion because of momentum or inertia. The peak load may be at the center of the movement, at either end or at both ends. Such conditions have a bearing on the location of the roller and its mounting.

Two simple cams are presented in order to simplify the analysis and to make the resultant conditions more evident. The same observations, however, apply to the more complicated cams. In this analysis the magnitudes of the loss component PR, load component AR, and cam thrust resultant AP are ignored. Since their relative magnitudes are dependent upon θ, this angle in itself indicates the best layout for different constructions. For convenience, the cam thrust is designated as P, the actuated load as R and the angle θ by a dimension arc. To aid visual comparison the radii of the arcs are the same in all figures, and the preferred rotation is shown by the solid arrows with the force arrows corresponding to the rotation indicated by the outer arrow.

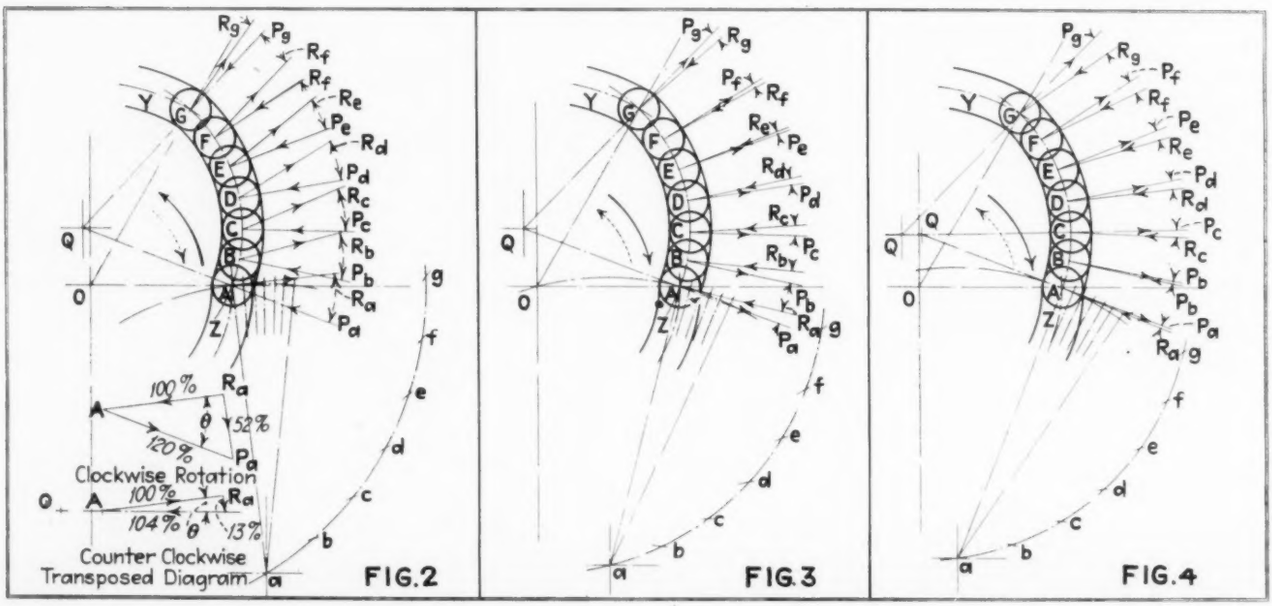
The face-type cams used in Figs. 2 to 6 have roller grooves for positive actuation in either direction. The minimum radius is 3 in., the rise is uniform from dwells Y and Z, the movement of $1\frac{1}{2}$ in. in 60 deg. is assumed to be produced by radii from centers Q. The roller diameter is 1 in., and the arm radius is 7 in.

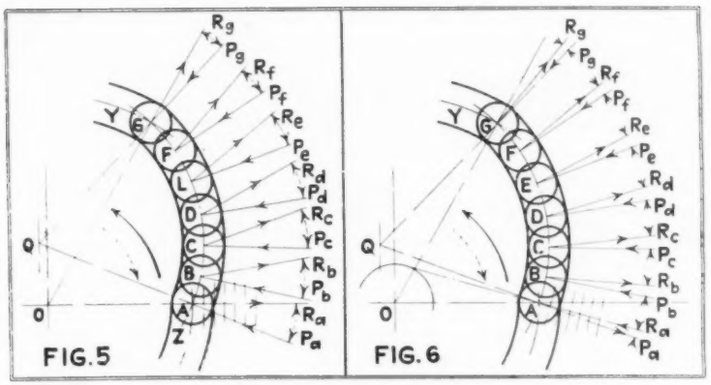
A layout indicating insufficient analysis is presented in Fig. 2. The fulcrum is located vertically below the center of the roller movement, occupying positions a, b, c, d, etc., for relative roller positions A, B, C, D, etc. The θ angles increase from a minimum at P_gR_g to a maximum at P_aR_a. At A the subtended component reaches 52 per cent of the actuated load component and the resultant actuating force is 120 per cent.

In analyzing clockwise rotation in Fig. 2, it is found that the transition from dwell Z to motion encounters the maximum θ angle P_aAR_a and that the angles decrease as the roller advances to G. At this point the angle between R_g and the extended line GO is small, indicating that the arresting force is almost directly opposed to the motion. The load factors to which this layout and rotation are best suited are: small inertia, load increasing during motion to a maximum at G with momentum to be overcome by the cam.

The counter clockwise rotation of Fig. 2 presents a different analysis. The small θ angle P_gGR_g indicates that the actuating force is nearly all available for overcoming inertia or other initial loads, but that an increasing proportion of the applied power is diverted as the motion progresses toward A. The change from motion to dwell Z is nearly as efficient as for clockwise rotation, the subtended component is only 13 per cent and the resultant 104 per cent of the load component; as shown in the transposed diagram. This motion ac-

Figs. 2, 3 and 4—The detrimental components can be varied by changing the position of the roller arm fulcrum. In this way the motion of the cam can be adapted to the requirements of its work cycle





Figs. 5 and 6—Changing the position of the sliding-type roller cam mounting varies the detrimental components

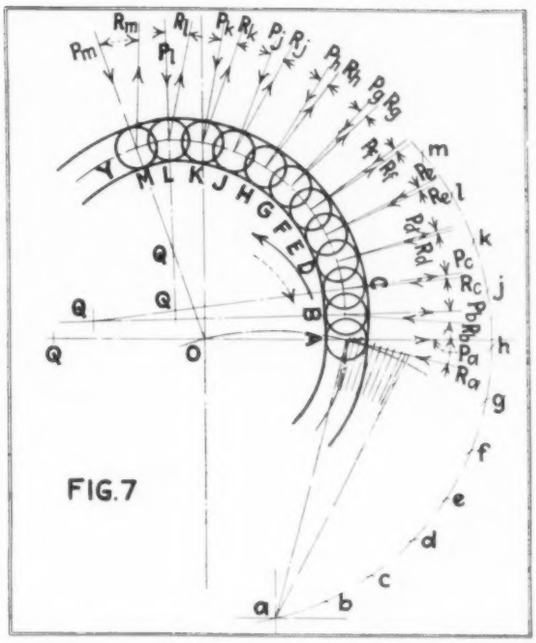


Fig. 7—A complex cam with accelerated and decelerated motion can be analyzed in the same manner as the simple cam

commodates a load with large inertia and momentum, and with a decreasing load under motion. Such an example is found in a machine with a rapidly reciprocating work table and machining a groove which grows shallower as the cut progresses.

In this layout neither rotation offers a satisfactory degree of efficiency. One favorable effect is that the θ angles become smaller as the movement increases from AO to GO. Counter clockwise rotation is preferred because the initial motion is more easily induced in this direction. Similar reasoning is applied to the other figures. In Fig. 3 the ideal conditions are nearly attained, for the θ angles are small and well equalized, the change compensating for increased moments. The preferred rotation, in the direction of the solid arrow, is efficient except at G, where the roller enters dwell Y. This layout and rotation will serve almost any load condition except one having excessive momentum, and is well adapted to an evenly distributed load. Rotation indicated by the dotted arrow encounters a large angle between R_a and the horizontal center line in entering dwell Z. This can be improved by moving the fulcrum to the right. Under most conditions the only further improvement lies in lengthening the lever Aa. Although the extended arc of motion passes through the cam center O, this does not always imply the best layout.

The fulcrum is moved further to the left in Fig. 4, and the extended arc passes above O. This layout is most suitable for resistance to initial motion, decreasing throughout the movement, little momentum and rotation clockwise. Such factors might be found in the operation of a toggle. The opposite rotation accommodates the opposite conditions except the inefficiency in entering dwell Z. However, with an increasing load, the tendency is to overbalance the momentum, offsetting the large angle between R_a and AO. The compression of a heavy spring is an example that fits the case.

Fig. 5 is a typical sliding mounting; all angles are large except those at entering dwells Y or Z. It is adapted to large momentum, small inertia and little resistance to continued motion. Rotation is optional, for the slight difference in θ angles balances the change in moments.

For loads of small inertia and momentum factors the cam shown in Fig. 6 is a considerable improvement. Still further improvement is obtained by increasing the slide angle until P_a coincides with R_a and P_g with R_g. Rotation in the direction of the solid arrow is preferred. An example is found in the actuation of a feed against a cutting tool operating with low work velocity.

In the above cases, cams of moderate rise and simple curvature are considered. As the rise per degree increases, the effects of the mounting are more pronounced. As the complexity of curvature increases, variations in the angles occur. Complexity of curvature, from centers $QQQQ$, is illustrated in Fig. 7 by a cam with accelerated and decelerated motions at the end of a uniform rise. The θ angles of this layout can be reduced by moving the fulcrum slightly to the right so that the motion arc passes $\frac{1}{4}$ in. below O. R will then be on the other side of P at the center of the node and the angles more nearly equalized.

For preliminary determinations it is not necessary to make an exact layout of the cam. A few points are located in the motion and a rough contour drawn with an irregular curve. Perpendiculars to tangents of the curve are drawn with sufficient accuracy to determine the mounting best suited to the design. After preliminary trials the design can be altered slightly in the final layout, if necessary.

The large θ angles result in bearing wear and strain on the parts. Vibration of the mechanism also results from large angles, for the wedging action of the cam causes deflections which in turn produce an alternate binding and releasing with sudden changes in velocity. Cam roller mounting and location cannot correct faulty cam design, but the operation of any cam is improved by a roller mounting that offers minimum resistance to motion induced by the cam contour.

Avoiding Duplication in Development Work

Five engineers tell how they keep abreast of new developments and outline their procedure to prevent the wasted effort of working on improvements previously invented

Gear Generators

A. L. STEWART
Chief Engineer, Gleason Works

► At the Gleason Works we depend on our patent department, on our files of prior developments in our field, and on current technical periodicals to check against re-invention. We have our own resident patent attorney.

We have a complete file of all U. S. patents relating to our field of work and, so far as possible, of all relevant foreign patents. In addition, we keep a file of leading magazine articles describing methods of cutting gears in different shops or describing new developments in this field. We also keep a file of catalogs covering machine tools generally and parts for such machines.

All gear articles and catalogs and all patents are classified according to a classification devised by ourselves, different from the Patent Office classification and based on our own practical requirements and experience. We endeavor to keep this classification flexible by addition of new sub-classes as new developments warrant them.

Very early in the development of an idea, a search is made to determine its novelty. This may come when the idea is first broached or perhaps when it has reached the point where layout work seems justified. Our search is used not merely as a guide against infringement but also in order to familiarize us with what has already been done. It is not infrequent that as a result of a search, modifications or improvements in the original idea may be suggested. An article detailing the experiences of a prior worker cannot but stimulate further thought on the problem and may often prevent a repetition of costly errors.

Throughout the course of design of a machine the chief engineer and standards engineer as well as the patent department keep in contact with the development. Thus there are several persons besides the designer aware of what is being done, and watching against the waste of time which might be incurred by an effort to invent a mechanism already known or in use.

We subscribe, of course, to a number of the technical magazines both domestic and foreign. These are checked over, as they are received, by both our patent department and by one of our engineers who is familiar with all work in process of design. Any article considered of special interest is called to the attention of the engineer who might be particularly concerned. The magazines are also placed at a central point in the engineering department so that they will be available to any interested engineer.

Another source of information is the salesmen who call upon us. We endeavor to make it possible for salesmen selling new improvements of general value in the machine tool line to have a ready access to our engineering department through our purchasing department, and we find that they bring us much valuable and usable information as to new developments besides enabling us to keep our machines equipped with the latest improvements and abreast of the latest designs.

Textile Looms

ALBERT PALMER
Research Assistant to the General Manager
Crompton & Knowles Loom Works

► As in other businesses, our development work and inventions here at Crompton & Knowles Loom Works have their inception in a need of some sort in the industry which uses our product. The results usually are obtained through one or both of two conditions; either an entirely new mechanism is conceived by someone, or an old mechanism is greatly improved through new manufacturing methods.

We have several agencies for following up new mechanisms. Our patent department receives copies of all the patents that are issued in our branch of the textile industry. These are carefully indexed after having been read and referred to members of our organization who are interested in the subject to which they pertain. We also have a committee known as the development board, made up of men representing the sales, the engineering, the manufacturing, the patent, and the administrative divisions of the company. This board receives and passes upon all ideas that are reported by the patent department, our representatives who are traveling

among the mills, and the various textile papers. A great many suggestions and ideas are offered by our customers and by inventors. This information, together with that which is accumulated from textile expositions and other miscellaneous sources, likewise is studied by this organization.

The improvement of existing mechanisms is stimulated not only by the procedure just outlined, but also by new manufacturing processes that are found to be available. We have a laboratory which is working constantly on metallurgical, chemical and physical problems relating to our manufacturing procedure. From time to time we send out visiting committees to study manufacturing plants in other types of industry. A few years ago we made an extensive study of foundries and foundry methods. Later we conducted a similar investigation of machine shops.

From salesmen who call here representing machine tool manufacturers and producers of equipment and materials, we learn of new methods that frequently make possible the improvement or redesign of our product. Through the various trade and technical magazines and societies we follow the work that is being done by other people.

Power Specialties

A. M. Houser
Engineer of Product, Crane Company

► In order to avoid duplication of work previously done in the industry by other engineers, we have made it a point to keep up with current inventions for many years by subscribing to the official patent publications of both the United States and Canada.

We also obtain copies of any pertinent patents from each issue thereof, and we maintain a classified article file of all patents obtained, both live and expired, for future reference. In addition, we make frequent searches of expired patents in the Patent Office in order to make certain that we are not overlooking past inventions which were previously avoided because of infringement.

Of course, we read all the latest trade and technical journals with the idea of watching new developments in the fields in which we work.

Electrical Equipment

R. C. Muir
General Engineering Department
General Electric Company

► In the General Electric Company we are organized in such a way that we automatically prevent any undue amount of waste from re-inventing methods and devices that have already been invented elsewhere, although we may never have heard of them. Our organization favors specialization on products or lines of products, so that the responsibility is centered in one department, the individuals of which are quite familiar with back history within our company and without on its particular product. Furthermore, the engineers are well supported by our patent department and, before involving any material expenditures on any new idea, they obtain a report from the patent department covering the situation in hand. In addition to this, the vice-president in charge of engineering has staff assistants to coordinate all the various departments and supervise to a degree all developmental programs.

Of course, we constantly bear in mind that any development which failed in the past might be successful today as a result of improvements or development of materials and processes, or further engineering knowledge. Consequently we encourage our young engineers by allowing them to spend a certain amount of time on developments, methods, or devices which either failed in the past or are at present covered by patents. This has the additional advantage of bringing in a new line of thought or a new approach to an old subject.

Automatic Lathes

J. E. Lovely
Chief Engineer, Jones & Lamson Machine Company

► It is difficult for anyone to be posted on all of the different things that have been done in the world in the past and especially all of the things that are going on at any one time, even in one narrow field. This will become evident to anyone who attempts a search in the Patent Office to see if a certain form of mechanism has been used previously. The original conception on which our patent law was based was the development of a scheme for enticing the inventor to disclose his inventions and record them in such a manner that they would be available to the general public. The patent office was intended to be the means for furnishing this information, and the plan was to build up this service for the benefit of the public.

The whole subject of patents has become so involved, however, that it is extremely difficult to find out by reference to the Patent Office all of the things that have been done or even that have been patented. There is such a mass of data on file and it is cross indexed and cataloged in such a manner as really to make it almost inaccessible.

Our own engineering department relies chiefly on its own files for keeping track of things that have been done in the past, not only in our own organization but in our whole field. We go to elaborate lengths in recording all of the work that we do in such a manner that our records will be reliable and accessible for some years to come. We have extensive files of patent history and have a routine method whereby one of our men reviews all new patents in our particular field.

Our whole sales and operating force, both in this country and abroad, continually advise us of new developments they encounter, which may possibly affect our product. Representatives from other companies, or individuals who have anything new which they think may be incorporated in our machines or may improve our product, are also constantly bringing these things to our attention.

We maintain an intimate knowledge of conditions in our customers' plants and an appreciation of their problems through the medium of our service and operating forces. Their function is to give users of our equipment the benefit of our knowledge and experience and assist them in the proper performance and operation of our machines.

Typical Anti-Friction

Third of a series of design work sheets showing

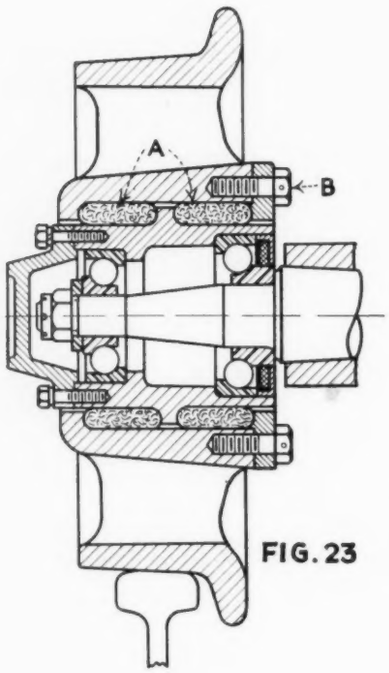
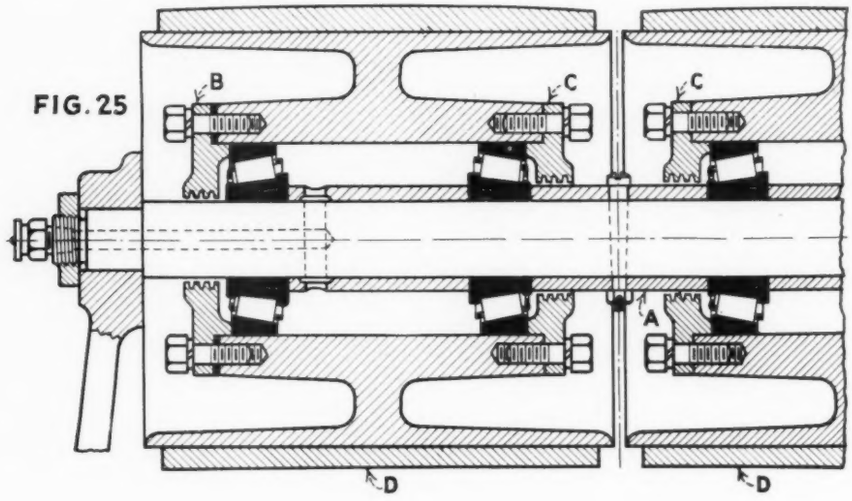


FIG. 23

FIG. 25



ADAM FREDERICKS

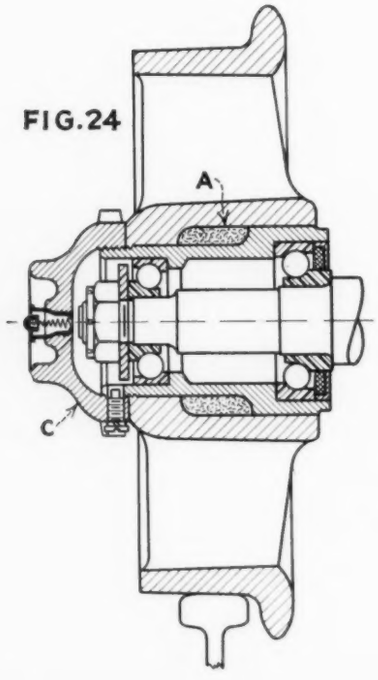
Fig. 23—Mine car wheels with rubber cushioning rings *A*, between separable hub and wheel. Cap is held by screws *B*. Removal of wheel does not expose bearings.

Fig. 24—Removal of Cap *C* permits slipping off wheel. Rubber ring *A* absorbs shocks.

Fig. 25—Double pulley mountings for belts *D-D*. Spacing sleeve *A* held by taper pin, caps *C* are screwed solidly, caps *B* are shimmed for adjusting bearings.

Fig. 26—Center shaft *A* is held stationary by tapered fit in arm *B*. Ring *C* holds lower bearing in place. Cup *D*, force fit on shaft, acts as a pocket for lubricant.

FIG. 24



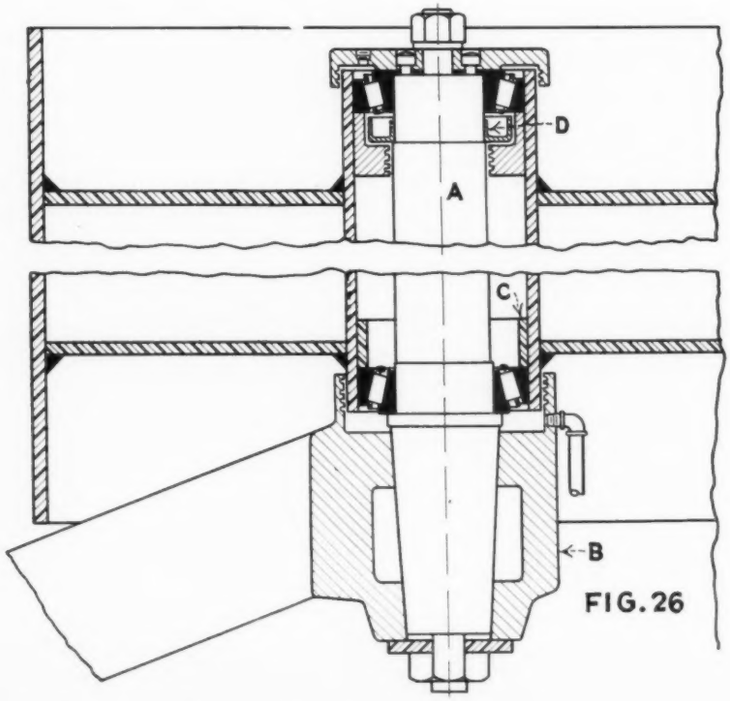


FIG. 26

Bearing Mountings—III

representative mountings for wheels and pulleys

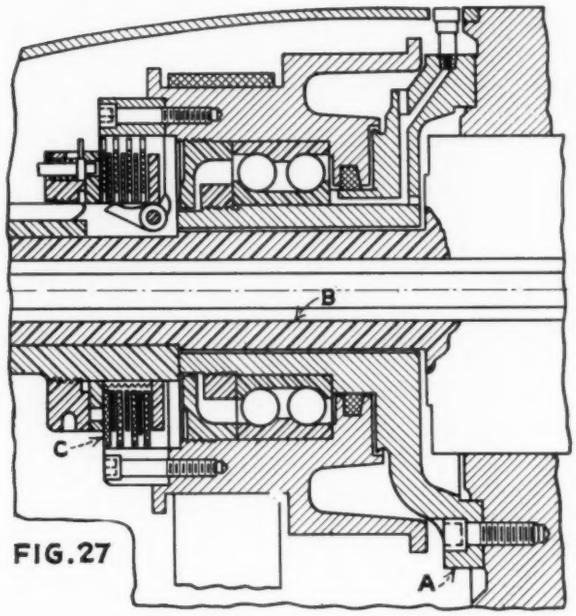


FIG. 27

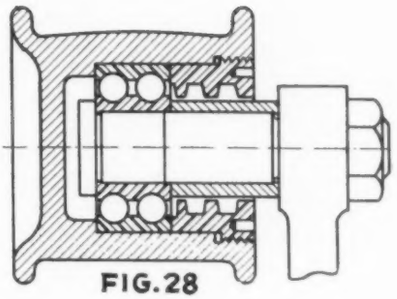


FIG. 28

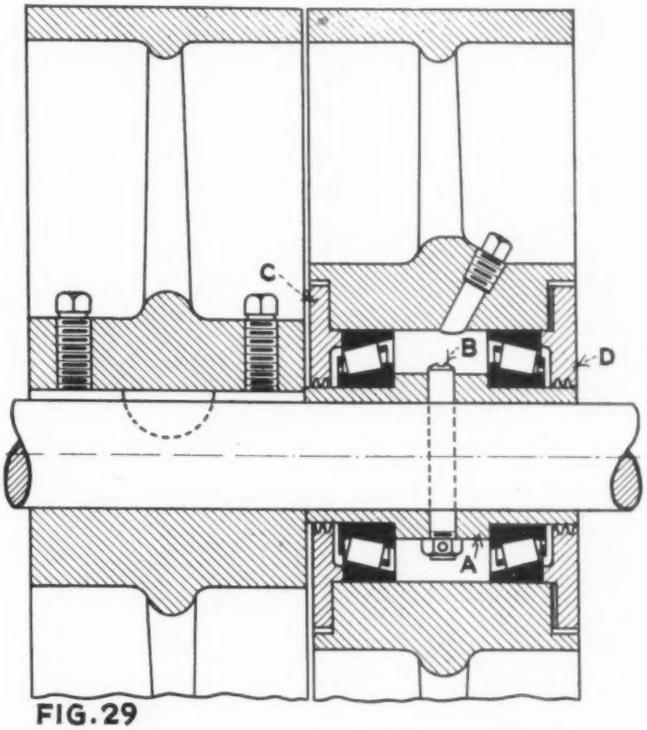


FIG. 29

Fig. 27—Two-step cone pulley with bearing supported in bracket *A*. Spindle *B* is driven through clutch *C*.

Fig. 28—Flanged pulley mounted on a stud shaft.

Fig. 29—Tight and loose pulley mounting. *C* and *D* are fastened with filister head screws. Sleeve *A* is held by pin *B*.

Fig. 30—Lathe drive pulley mounting consisting of bearing bracket *A*, locknut adjustment *B*, sealing ring *C*, drive shaft *D*, clutch driving member *F*, pins *G* and driven member *H*, spool *M* and clutch rod *N*. Internal teeth *K* of pulley *L* engage clutch disks J_1.

Fig. 31—*A* and *B* are adjustable to take up V-belt slack. Dog-pointed setscrew *C* engages slot *D*.

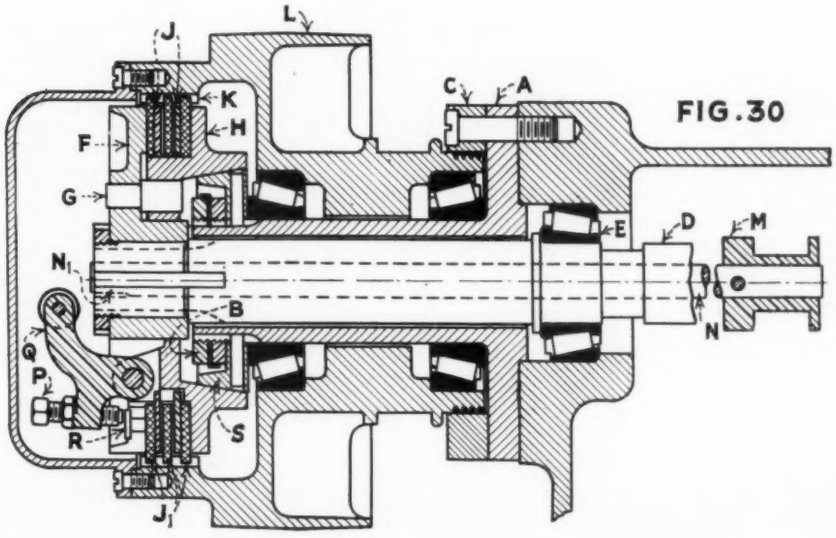


FIG. 30

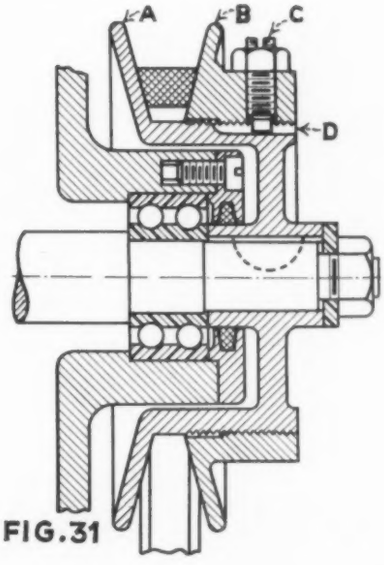


FIG. 31

The Chrome and Chrome-Nickel Iron Alloys—I

A classification of these alloys into four main divisions, giving their corrosion resistant and physical properties, their fields of application and the heat-treatments required

T. HOLLAND NELSON, *Consulting Metallurgist, Philadelphia, Pa.*

RECENTLY compiled data charts, such as published by the leading technical societies, list several hundred different trade names or classifications of so-called stainless steels. It is not, therefore, at all surprising to find the designing engineer in somewhat of a dilemma as to how to approach with confidence the selection of a material suitable for any specific purpose.

Inasmuch as the original Brearley Stainless Steel, covered by a patent ranging from a chromium content of 9 per cent to 16 per cent, was responsible for the original terminology "stainless," let us revert to data available, review for a moment the effect of adding various increasing percentages of chromium to mild steel and observe how the solubility is decreased and the passivity increased in solutions of nitric acid as the chromium content is advanced. This is shown in the accompanying table.

Effect of Chromium Content on the Action of Nitric Acid on Steel

COMPOSITION OF STEEL		"NORMAL" ACID		S. G. 1.20 ACID	
Carbon Per Cent	Chromium Per Cent	Per Cent Loss in 5 Hr.	Mgm. per Sq. Cm. per Hr.	Per Cent Loss in 24 Hr.	Mgm. per Sq. Cm. per Hr.
0.16	nil	5.57	16.20	39.9	1.250
0.14	4.7	1.95	15.65	2.0	1.640
0.12	6.2	1.60	13.50	0.082	0.064
0.09	7.5	2.07	6.15	0.006	0.005
0.16	10.0	0.785	2.10	trace	trace
0.15	10.9	0.295	0.88	nil	nil
0.09	12.0	0.122	0.35	nil	nil
0.14	13.1	0.026	0.08	nil	nil
0.09	14.0	0.0097	0.03	nil	nil
0.10	15.5	nil	nil	nil	nil
0.13	17.5	nil	nil	nil	nil

Chemical Analysis

In attempting to give any details regarding chemical analysis of stainless or corrosion-resistant alloys, one would be confronted with quoting something like 250 to 300 various brands of material. These, however, can all be brought, more or less, within four definite groups. It is a point such as this with which the designing engineer is vitally concerned. This classification of these alloys appears to be far from well understood, and yet it is a fundamental governing the type of corrosion-resistant alloy that might be suitable for a specific purpose. These four major classifications are shown in the accompanying table.

Classification of Corrosion-Resistant Iron Alloys

A—Iron with varying percentages of chromium.
B—Iron with varying percentages of nickel.
C—Iron with varying percentages of chromium with nickel present in somewhat smaller proportions than the chromium.
D—Iron with nickel present and chromium also present in smaller proportions than the nickel content.

There are also a few alloys available and in service containing almost equal proportions of chromium and nickel, the balance being iron, such, for example, as an alloy of from 19 per cent to 21 per cent nickel and a similar amount of chromium.

Simple Alloys of Iron and Chromium

Typical analyses of alloys included in Classification A would be found among the three groups in the accompanying table. These three groups of alloys are to be found in every-day commercial use in the various fields of corrosion resistance; the choice in selection of any particular one depending substantially upon the mechanical and physical properties required.

Experience has taught me that there is one striking feature of the straight chromium stainless irons or steels that is not well understood by engineers. That is, with low carbons throughout, say a maximum of 0.15 per cent, there is a sharp line of demarcation in the neighborhood of 16 per cent chromium which definitely separates these types of alloys into two classes. Materials of this type, containing below 16 per cent

Corrosion-Resistant Iron Alloys
Classification A

	1	2	3
Carbon	0.05/0.50	0.12/0.50	0.25/0.70
Silicon	0.25/1.00	0.25/1.00	0.25/1.00
Manganese	0.25/0.75	0.25/0.75	0.25/0.75
Sulphur	0.03	0.03	0.03
Phosphorus	0.03	0.03	0.03
Chromium	11.00/14.00	17.00/19.00	24.00/28.00
Vanadium	Optional	Optional	Optional
Molybdenum	Optional	Optional	Optional
Titanium	Optional	Optional	Optional

chromium, are more or less susceptible to heat-treatment. In the language of the metallurgist they are allotropic, have definite transformation points, and can be hardened on quenching and drawn on tempering. In other words, the physical properties are subject to adjustment by heat-treatment.

Above 16 per cent chromium, however, with this same low carbon content, the materials are in practically all phases, what is known as ferritic chromium irons. If they have a transformation point it is so far removed from the commercial working ranges and so close to the melting point that it is quite safe to state that such material is not susceptible to heat-treatment and that the physical properties cannot, with certain qualifications, be adjusted by heat-treatment. Thus, hardening will not increase the tensile properties, nor will tempering reduce them.

The qualification referred to above is that these alloys, containing more than 16 per cent chromium, are susceptible to work hardening; that is, varying physical properties can be obtained by regulating the amount of mechanical work put upon them. The accompanying tables give an idea of the physical properties to be found by an adjustment of carbon in the Group 1 alloys of Classification A.

The physical properties of type A-2 are fairly well illustrated in the accompanying tables.

These tables clearly show that the material in the "as rolled" condition possesses its highest physical properties, which are in proportion to the amount of mechanical work done upon it. Heat-treatment in no case materially increases these physical properties, but reduces them to a common unit which practically remains unchanged. This explains why elevated temperatures produce enlarged grain growth and subsequent mechanical weakness in the alloys that fall in Group 2—Classification A.

The mechanical properties of the alloys in Group 3—Classification A fall within the range as given in the following table:

Physical Properties of Alloys in Classification A—Group 3

Maximum Stress	90,000/130,000
Yield Point	50,000/100,000
Elongation per cent in 2 in.	35/10
Reduction of Area	50/25
Brinell	150/200

The lower chromium group, as covered by Classification A—Group 1, are particularly adapted to general engineering purposes where mechanical properties are of paramount importance and some slight concessions with regard to corrosion resistance can be made in order to obtain definite mechanical properties. This type of material is usually for such applications as turbine blading, cutlery, pump shafts, hydraulic rams, and various engineering parts calling for definite mechanical properties.

The material is in its most favorable condition to resist corrosion after quenching from approximately

Properties of Corrosion-Resistant Iron Alloys
Classification A—Group 1
Low Carbon

ANALYSIS

Carbon	0.07 per cent	Silicon	0.08 per cent
Manganese	0.12 per cent	Chromium	11.70 per cent

OIL HARDENED FROM 1,700 DEG. F. AND REHEATED AS SHOWN BELOW FOR THE PHYSICAL PROPERTIES REQUIRED

Reheating Temp. Deg. F.	Elastic Limit	Ultimate Strength	Per Cent Elong.	Per Cent Red. Area	Izod Impact	Brinell
400	—	163,500	12	38	34	340
575	—	162,200	12	36	38	332
750	—	162,200	15	51	38	332
925	131,700	162,200	18	52	36	340
1,100	85,100	109,700	22	62	65	241
1,300	68,500	90,500	26	66	79	196
1,400	62,700	81,500	31	69	87	179

Properties of Corrosion-Resistant Iron Alloys
Classification A—Group 1
0.35-0.45 Carbon

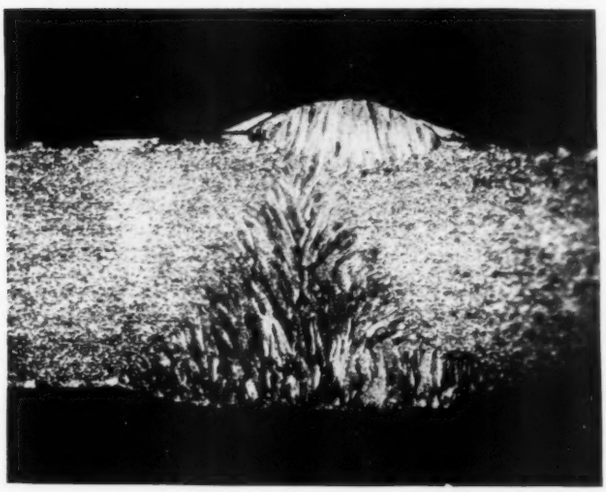
ANALYSIS

Carbon	0.35 to 0.45 per cent	Silicon	0.19 per cent
Manganese	0.15 per cent	Chromium	12.00 per cent

AIR HARDENED FROM 1,700 DEG. F. AND REHEATED

Reheating Temp., Deg. F.	Elastic Limit	Ultimate Strength	Per Cent Elong.	Per Cent Red. Area	Izod Impact	Brinell
925	—	232,900	9	24	8	444
1,100	126,300	141,100	15	42	15	285
1,300	104,800	120,900	21	52	30	241

To the left is shown a macrophotograph (× 3 diameters) and to the right a microphotograph (× 100 diameters) showing the structure of weld metal and parent metal in 17.00 per cent chromium iron



1,750 deg. F.; that is to say, in the fully hardened condition with all carbides in solution. Any tempering to which the material is later subjected, while reducing the tensile and increasing the ductility at the same time depreciates to some extent the resistance of the material to corrosive attack.

This material is not readily adapted to general construction work because of the fact that it is susceptible to hardening and tempering. It is practically impossible to weld it satisfactorily, as both the weld metal and the metal adjacent to the weld harden considerably. For this reason the weld is susceptible to the development of cracks before the metal can be heat-treated. This fact also plays an important part in riveting. One can quite readily appreciate that a hot rivet of this material driven into two cold plates hardens to such an extent that the rivet head can be knocked off with a single blow from a hand hammer. However, this material has undoubted commercial value and, as stated above, is extensively used in a variety of fields.

Material of the Classification A—Group 2 type has been found readily adaptable to general construction

Properties of Corrosion-Resistant Iron Alloys
Classification A—Group 2
Size of Specimen, 1⅛ In. Diameter

ANALYSIS

Carbon	0.09 per cent	Silicon	1.28 per cent
Manganese	0.35 per cent	Chromium	18.50 per cent

Tempering Temp. Deg. F.	Elastic Limit	Ultimate Strength	Per Cent Elong.	Per Cent Red. Area	Brinell
As rolled	77,000	95,000	27.0	67.0	197
100	79,000	97,300	27.0	65.9	196
500	77,000	98,000	27.0	67.0	207
725	76,400	97,200	27.0	63.3	212
1,000	81,500	99,800	26.0	64.0	207
1,250	78,300	96,000	26.5	63.6	207
1,500	52,400	78,400	36.0	73.5	156
1,750	56,900	79,900	31.0	68.2	167

WATER QUENCHED FROM 1,800 DEG. F. AND REHEATED

Reheating Temp., Deg. F.	Elastic Limit	Ultimate Strength	Per Cent Elong.	Per Cent Red. Area	Brinell
As quenched	55,000	77,300	36.5	70.4	156
100	56,400	76,900	33.0	73.5	156
500	56,900	77,900	36.0	71.5	156
700	54,900	74,900	35.0	72.9	152
1,000	57,400	83,400	31.0	65.9	159
1,250	50,000	76,000	35.5	71.4	156
1,500	50,900	74,900	36.5	76.5	146
1,750	50,000	76,000	36.0	71.4	179

work and of all the Cr-Ni corrosion-resistant steel in service in the chemical industry, fully 90 per cent is of this particular type.

In the hands of the fabricator this material works quite readily and can be handled, generally speaking, by any reliable manufacturer of tanks, stacks or general structural work. The material can be welded, although it should be distinctly understood that the weld metal is of large crystalline structure and to this extent is somewhat mechanically weak. But there is no tendency for hardening cracks to develop and the corrosion resistance of both weld metal and adjacent metal under practically all oxidizing conditions has proved quite satisfactory. However, practical experience to date has rather steered away from welding because of the mechanical weakness of the weld metal, and the majority of the structural installations built from this type of material are of riveted design.

In applying heat to this material, for the purpose of fabrication, it is strictly advisable to keep the maximum temperature below 1,450 deg. F. Practically all operations, such as applying local heat for flanging or local deformation, can be carried out well below this temperature. It is possible to use higher temperatures, providing the temperatures are not maintained long enough to allow grain growth to develop. It should be clearly understood that where temperatures high enough to allow grain growth are used, mechanical weakness follows.

Classification A—Group 3 is used to combat conditions of extremely severe corrosion and also in the field of heat resistance. It is rather a delicate material to handle in the hands of the fabricator and on this account its development has been somewhat restricted.

The material is practically immune to heat-treatment and even after all mechanical stress has been released the material as received by the fabricator from the steel manufacturer is by no means easy to handle. The structure is more or less highly laminated, and in general working operations the material has a tendency to crack and spall along the fibers. In the hands of the most experienced workers, however, this material can be fabricated. Welded structures, as well as riveted structures, have been produced, though extreme care is required. Since all the precautions that apply to type A-2 are absolutely necessary in handling type A-3 material, it is fortunate that only in extreme circumstances is this particularly high chromium content called for in the general structural field.

Machinability

All the foregoing materials can be machined without difficulty when proper regard is paid to the chromium content. Any materials containing this amount of chromium offer considerable abrasion resistance to cutting tools. It is, therefore, generally found advantageous to reduce cutting speeds, and if this is done depth of cut and traverse can usually be fairly well maintained.

In specifying alloys of the straight chromium group, whether they be of the hardening or non-hardening type, one should remember that if they are maintained at temperatures of approximately 775 deg. F. to 950 deg. F. gradual embrittlement takes place. The actual cause of this embrittlement still seems to be surrounded with considerable doubt. Beyond the fact that brittleness will occur in the straight chromium alloys if they are maintained in the temperature zone of 775 deg. F. to 950 deg. F., the time required to produce this embrittlement varies in proportion to the chromium content. The lower chromium contents seem to offer greater resistance to embrittlement than those of the higher percentages.

While referring to the subject of embrittlement, it should be added that although these straight chromium alloys do become brittle when operating in the temperature cycle referred to, they can, nevertheless, be readily restored to their former degree of ductility and toughness by a simple heat-treatment, such as an air quench from a temperature in the range of 1,250 deg. to 1,400 deg. F.

EDITOR'S NOTE—*In the August number the author will discuss the remaining three members of his classification of corrosion-resisting irons and steels and will give detailed information concerning the workability of these alloys.*

Why Threaded Parts Fail

Photo-elastic analysis of threaded connections discloses concentrated stresses large enough to cause fatigue failure even with apparently large safety factors

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IT IS customary to assume a uniform load distribution across the bolt section when calculating the working stress on a bolt. The assumption seems to be justified by the fact that a tensile test of a threaded connection fails either by shearing off of the threads or by tensile rupture in the bolt. In fatigue tests and in service under reverse loading, however, failure at the thread root is common, indicating that a high stress concentration exists at this point. The magnitude of these local stresses is influenced by so many variables that theoretical analysis would be of doubtful value. Photo-elastic analysis, however, provides the answer in a form that indicates directly the intensity of these concentrated stresses, and shows how these stresses are influenced by different thread shapes.

Since photo-elastic methods require a two-dimensional model, it is impossible to make a quantitative analysis of the three-dimensioned stresses present in screw threads under load. Relative stress distribution, however, can be determined with satisfactory accuracy by using a model representing a cross-section through the bolt axis.

Fig. 2—Shear stress distribution in a bolt and nut is clearly indicated by this photo-elastic fringe photograph

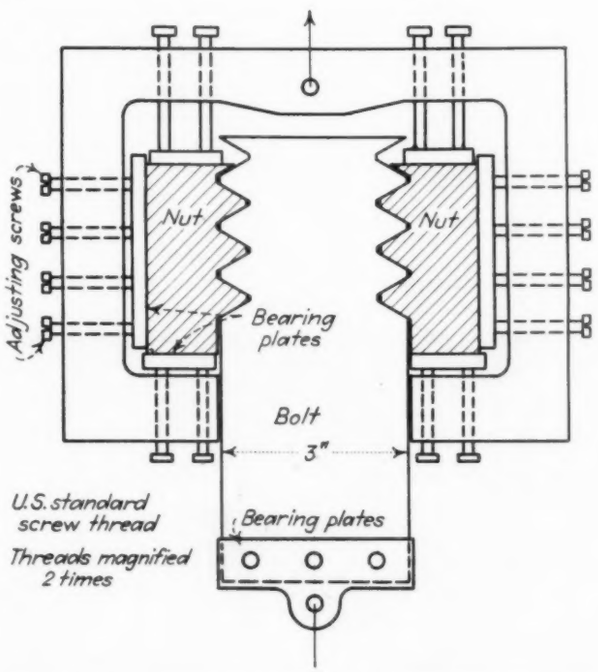

Fig. 1—Bakelite model of a bolt and nut with three threads in contact mounted in the adjustable loading frame

Photo-elastic models were prepared from clear bakelite 0.385 in. thick, annealed after machining, to remove internal stresses. The models were assembled in the loading frame shown in Fig. 1, which was provided with adjustable bearing plates to hold the parts in alignment under load. Two segments of the nut are shown on either side of the bolt representing a cross-section through the axis of the threaded connection. This is a model of an American Standard threaded bolt and nut with the thread dimension enlarged two times.

Because of practical difficulties arising in the machining of the thread, it was impossible to obtain a symmetrical distribution of the stress fringes over the model. Some defects in machining the model were corrected by observing the model under polarized light, and hand fitting the parts so that local stress concentrations were eliminated. When the model was loaded and examined under polarized light, the stress

fringe pattern as shown in Fig. 2 indicated that the stresses at the root of the thread vary slightly along the length of the threaded section. The strengthening effect of the bolt shank reduces the stresses in the first thread, while the stress intensity in the other threads is increased by the load on adjacent ones. Although in actual service the number and length of thread surfaces in contact are much greater than in the model, surface irregularities and slight variations in pitch of the machined threads will result in localized stresses of relatively large magnitude.

In the fringe photograph, Fig. 2, the closely crowded fringes identify the points at which fatigue failure may originate. The illustration shows that the fringes reduce to small dots or closed curves at the corner of the root boundary, where the shear and bending forces are combined. Where the surfaces are in partial contact, these values are further magnified.

Each fringe line in Fig. 2 is a zone of constant maximum shear stress and each successive fringe represents an increase of 182 lb. per sq.in. in the shear stress. The maximum shear stress, found at the boundary line of the root, is 1,230 lb. per sq.in. The stress concentration factor or the ratio of the maximum unit stress to the average unit stress across the bolt section shown in Fig. 2 is 3.95 for the model illustrated.

The stress concentration factor was determined for three types of threads: Sellers square, American Standard and Whitworth thread. The models were prepared similar to the ones shown in Fig. 1 and in each test were loaded in the same manner. Because of the practical difficulties involved in securing uniform load distribution on several threads, these models were provided with only one thread in contact. In Fig. 3 are the fringe photographs for these three models. In the square thread large concentrated stresses are produced at corners of the root of the thread, as well as around the square edges of the thread in contact. The heaviest stress is at the compression corner of the root, where the stress concentration factor is 7.6. This factor is considerably larger than the usual factor of safety assumed in designing such threads.

Fewer areas of concentrated stress and fewer stress fringes are found in the model of the American Standard thread. The stress concentration factor of 3.8 of the critical point at the root of the thread compares favorably with the factor of 3.95 found in the first model with multiple thread contact. Stress concentration factors of such values indicate that with a normal factor of safety there may be parts of the bolt where the stresses are beyond the ultimate strength of the material. Poor surface finish on the thread combined with a reversing load is favorable to starting a fatigue crack, which may ultimately cause failure even when a conservative factor of safety is used.

In the Whitworth contour with curved roots and thread ends, the direct bearing of the curved edges of the bolt against the curved surface of the nut thread produces local stress concentration. However, the stress concentration factor of the critical point is only 2.9, a reduction of 24 per cent from the value found for the American Standard threads.

The distribution of maximum shear stress across the section of the bolt is shown in Fig. 4 for the three types of thread contours. This curve shows very clearly the necessity for using higher factors of safety in the design of the square threads, and indicates the superiority of the Whitworth over the American Standard thread under conditions conducive to fatigue failure. The relative stress concentration effect for the Whitworth, American Standard, and Sellers square thread is 1:1.3:2.6. Expressed in another manner, to produce a given maximum stress in the bolt, the relative load on the bolt is: Whitworth thread, 100 per cent; American Standard, 76 per cent; Sellers square. 38 per cent.

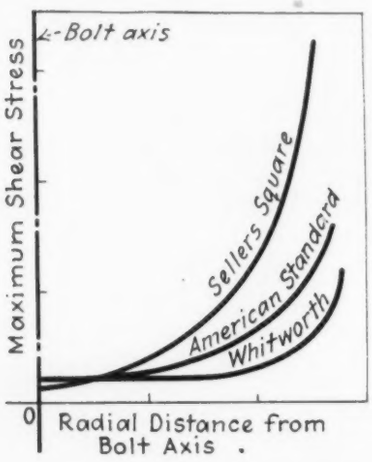

Fig. 4—Maximum shear stresses across the bolt axis show clearly the danger of assuming a uniform stress distribution

Fig. 3—Areas of high stress concentration are indicated by the crowded fringe lines on these models of Sellers square, American Standard, and Whitworth threads

Four Zinc Alloys for Die-Castings

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Although as a result of recent metallurgical advances, numerous zinc die-casting alloys have been developed to meet specific exacting requirements, one or the other of the four alloys described here will be suitable for most applications

▼

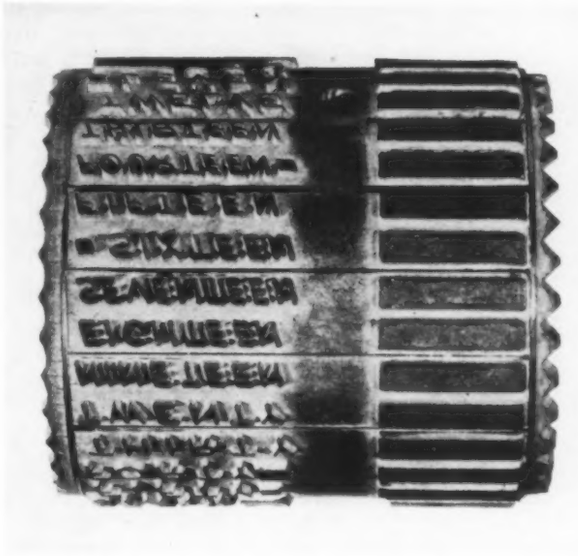
BECAUSE few metals have physical properties that make them suitable for a wide range of die-casting applications, and because of the need for a universal die-casting alloy, metallurgical effort has been devoted mainly toward the development of such alloys. With particular reference to zinc alloys for die-casting, such materials must have not only the proper physical and corrosion-resistant properties, but, in addition, the metal must have such properties that it will not score the mold, will have high fluidity at relatively low temperatures, and will not be subject to excessive aging effects after solidification.

Table I presents the results of some tests that emphasize the effect of alloying pure zinc. The first two materials were cast at high pressure to compensate for their low fluidity, a fact that favorably influenced the properties given.

Alloying zinc with a small amount of aluminum prevents the scoring action of the zinc on the metal mold, and, in addition, the aluminum increases the tensile strength, impact resistance, and ductility. This is clearly shown by the data given in Table I. Aluminum also increases the fluidity of the zinc, making it possible to fill out thin sections and elaborate designs without excessive pressures. Higher fluidity in the metal results in better surfaces and castings free from cracks. Improved machinability of the zinc die-casting alloy is also brought about by the addition of aluminum. Any iron present in the melted die-casting metal combines with the aluminum forming a light aluminum-iron alloy that floats to the top.

TABLE I
Illustrating the Effect of Adding Copper or Aluminum to Zinc

	Zinc 99.99+ per cent Purity	Aluminum-Free Alloy 1 per cent Cu, 0.2 per cent Ag. Remainder Zinc	Copper-Free Alloy 4 per cent Al, 0.05 per cent Mg. Remainder Zinc
Tensile Strength, lb. per sq.in.....	10,000	17,000	36,000
Impact Strength, ft.-lb.....	1.25	4.25	18
Brinell Hardness....	31	47	62
Per cent Elongation.	3.0	2.5	4.5



Fluidity as well as resistance to wear and corrosion are required of the material used for this die-cast printing cylinder for a check-writer

A small percentage of copper added to counteract certain impurities in the zinc, although increasing the physical properties, causes undesirable aging changes. Castings made from copper-zinc alloys undergo with age an appreciable loss of impact resistance and tensile strength, and in addition are subject to slight dimensional alterations amounting to about one-tenth of one per cent in the course of several years.

Using zinc of 99.9+ per cent purity, a copper-free alloy containing 4 per cent aluminum and a few hundredths per cent magnesium, listed as Alloy 3 in Table II, is opening up new fields of use for die-casting. The tensile strength of this alloy is ample for most purposes for which die-castings are used. Its impact strength is sufficient to withstand severe abuse without breakage, and parts die-cast from this material can undergo extensive deformation without fracture. The absence of copper eliminates the aging changes in the physical properties and reduces the dimensional changes to a point where they are negligible. If necessary, the dimensionl changes can be eliminated entirely by aging for a few weeks at room temperature, or by annealing

for several hours at a temperature between 70 and 100 deg. C.

No single zinc alloy has been developed that is suitable for all die-casting purposes. Four compositions are given in Table II. The first two of these alloys are included in the specifications of both the American Society for Testing Materials and the Society of Automotive Engineers. Alloy 2, the oldest of the four, when compared with those developed more recently, is inferior in impact strength, permanence of dimensions and permanence of physical properties, but before aging has higher tensile strength. Alloy 3 is the copper-free alloy already described. Alloy 5 has a higher tensile strength, but a lower impact strength than any of the other three materials. Alloy 6 is less hot short than other alloys, and consequently in some dies is more readily cast without danger of fracturing during cooling. It is also more malleable and more suitable where riveting operations are to be performed in assembly, but is less stable than the other alloys.

When exposed to outdoor weathering for long periods of time, zinc alloys undergo a surface oxidation. For protection from weathering, the surface of die-castings can be plated with chromium, nickel, or cadmium, or the surface can be protected by lacquer or enamel. If extensive corrosion rather than mere tarnishing limits the useful life of a die-casting part, each application presents a separate problem. Although no metal or alloy is yet available which is uniformly superior under all corrosion conditions, zinc and zinc alloys have sufficient corrosion resistance to be serviceable under a wide range of common service conditions.

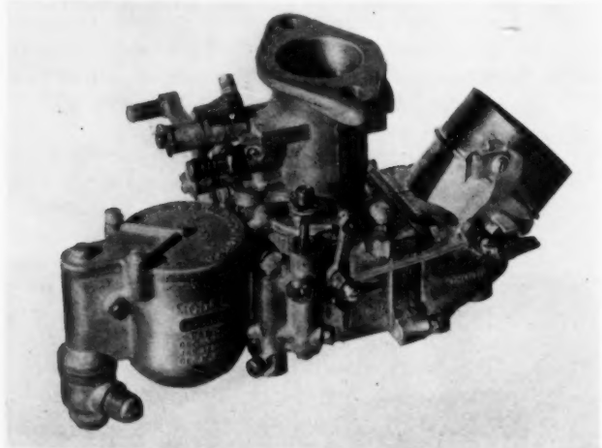
Zinc die-casting alloys are subject to no greater tendency to intercrystalline corrosion than other zinc alloys that do not contain aluminum. In fact, the aluminum-zinc die-cast alloys with magnesium, and free from impurities, such as lead, tin and cadmium, have greater resistance to intercrystalline corrosion than many other metals and zinc alloys.

Every successful product must meet the requirements of the service for which it is intended. Through recent metallurgical and mechanical advances, die-castings can now be produced to satisfy increasingly exacting requirements of strength, ductility, fluidity and permanence of physical properties and dimensions. To the designer, the problem is one of specifying the most suitable alloy.

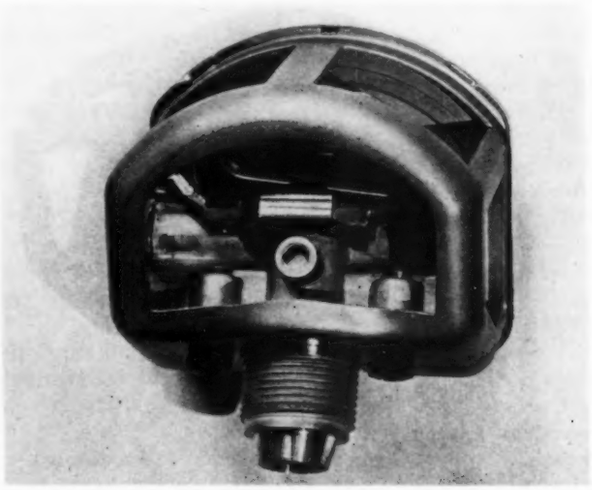
TABLE II
Composition and Properties of Four Zinc Die-Casting Alloys

Zinc, 99.99+ per cent purity. Original properties and contraction determined 6 months after casting. Properties after aging determined after 2 years indoors.

	Alloy 2	Alloy 3	Alloy 5	Alloy 6
Composition				
Aluminum...	4 per cent	4 per cent	4 per cent	4 per cent
Copper.....	3 per cent	None	1 per cent	1.25 per cent
Magnesium..	0.03 per cent	0.04 per cent	0.03 per cent	None
Zinc.....	Remainder	Remainder	Remainder	Remainder
Properties				
Tensile Strength, lb. per sq.in.				
Original...	47,000	36,000	41,000	39,000
After aging	48,000	34,000	39,000	38,000
Impact Strength, ft.lb.				
Original...	15.0	19.5	17.7	18.5
After aging	9.2	18.7	17.7	18.5
Brinell Hardness				
Original.....	83	63	73	71
After aging	100	68	76	78
Elongation, per cent				
Original...	8.4	5.3	4.2	10.6
After aging	6.6	6.9	4.4	9.8
Contraction of 6-in. bars, in.....	0.0006	0.0004	0.0005	0.0004

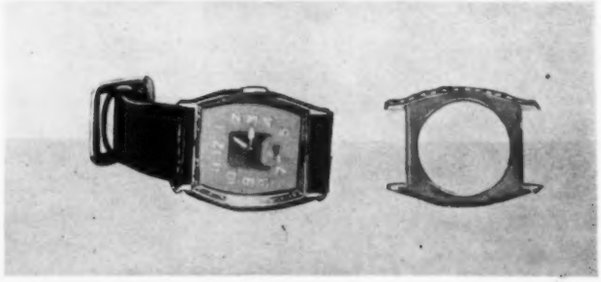


Permanence of physical qualities, ductility and freedom from porosity, corrosion resistance, are requirements met by the die-casting alloy used in an automobile carburetor



Speedometer frame of die-castings saving many machining and assembly operations

Decorations on this wrist-watch case require fluidity in the die-casting metal



Strength of Undercut Teeth

HANS SCHEMM

ALL hob-cut gears having 14½-deg. pressure angle and standard tooth dimensions have undercut teeth when the number of teeth is less than 37. The following formulas were developed for determining the size and location of this undercut section. Referring to Fig. 1, curve No. 1 is the curve of the tooth involute and curve No. 2 is the curve developed by the tip of the cutting tool. The following notations are used:

ϕ = pressure angle in deg.
ω = generating angle of the involute curve in radians
ω_d = generating angle of the involute curve in deg.
ψ = generating angle of the undercutting curve
φ = 51 min., 14 sec. for 20 deg. pressure angle
= 19 min., 4 sec. for 14½ deg. pressure angle
k = addendum of hob
n = number of teeth
t = thickness of modified tooth at pitch circle
c = width of the weakest section
s = distance of weakest section from center of gear

From the figure:

$$AB = k \sin \phi, \qquad AD = r \sin \phi, \qquad DB = \omega r \cos \phi$$
$$(r - k) \sin \phi = \omega r \cos \phi$$
$$\omega = 1/r\,(r - k) \tan \phi \qquad (1)$$

For standard tooth dimensions,

$$\omega = 1/n\,(n - 2.3142) \tan \phi$$
$$\beta = 90/n$$

Referring again to the figure,

$$\eta = \alpha + \beta + \varphi \qquad \alpha = \phi + \omega_d$$

The equation of curve No. 2 is found by superposition to be

$$x = r\,(\sin \psi - \psi \cos \psi) - k \sin \psi \qquad (2)$$
$$y = r\,(\cos \psi + \psi \sin \psi) - k \cos \psi \qquad (3)$$

In order to find the smallest distance between the curve No. 2 and the center line OL of a tooth, a tangent to the curve No. 2 at P must be parallel to OL. Differentiating Equations (2) and (3), and substituting in the equation of the tangent, we get the following:

Equation of the tangent is

$$(y - y_o)\frac{dx}{d\psi} - (x - x_o)\frac{dy}{d\psi} = 0$$

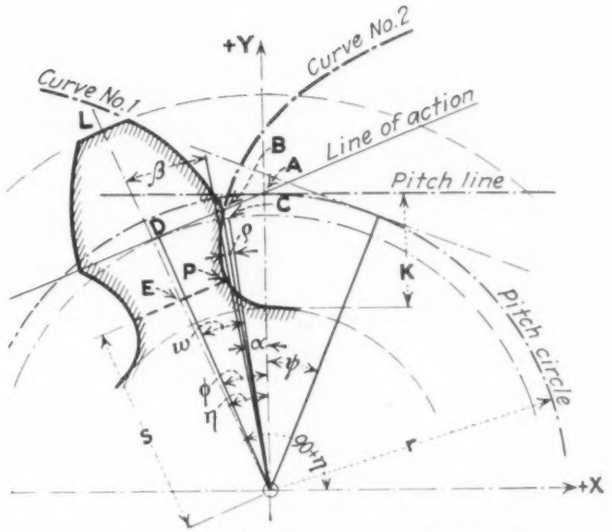
$$\frac{dy}{d\psi} = \frac{dx}{d\psi} \tan (90 + \eta)$$

Substituting for dx and dy as obtained by differentiating Equations (2) and (3), we get:

$$r\psi \cos \psi + k \sin \psi = -(r\psi \sin \psi - k \cos \psi) \cot \eta \qquad (4)$$

For numerical evaluation Equation (4) is changed to:

$$z = r\psi \cos \psi + k \sin \psi + (r\psi \sin \psi - k \cos \psi) \cot \eta \qquad (5)$$



Dimension c and its location s are determined by equations given in the text

The value of ψ found by solving this equation, substituted in Equations (2) and (3) gives the point of tangency P in terms of the coordinates x_0, y_0.

To illustrate this method the smallest section is calculated for a 6-tooth pinion with a 2-in. diametrical pitch and 20-deg. pressure angle. By simple trigonometry the width of the weakest section is:

$$c = 2\,(y_o \sin \eta - x_o \cos \eta) \qquad (6)$$

The distance of the smallest section from the center,

$$s = x_o \sin \eta + y_o \cos \eta \qquad (7)$$

Since x_0 in Equation (2) will be negative, in accordance with the layout in the figure, its positive value has to be substituted in Equations (6) and (7). For the illustration used,

$$r = 1.5,\ \omega_d = 12°\,48'\,40'',\ \alpha = 7°\,11'\,20'',\ \beta = 15°,\ \eta = 23°\,2'\,34''$$

To solve Equation (5) it is necessary to find by trial the angle which makes z equal to zero, which in this example gives $\psi = 22°\ 2'\ 14''$. Substituting this value of ψ in Equations (2) and (3) gives the point of tangency P, having the coordinates: $x_0 = -0.189$, $y_0 = +1.071$.

Substituting these values of x_0 and y_0 in Equations (6) and (7) gives $c = 0.490$ in. and $s = 1.059$ in. Knowing the position and dimensions of the weakest section, the safe load on the undercut gear tooth can be calculated with accuracy.

Decoration Must Be Appropriate

Based on twenty years of experience in putting "charm" into the engineer's designs

J. WOODLEY GOSLING, *Decorative Designer, General Electric Company*

AN ENGINEER once remarked to me as he completed a working model for a new device, "Here it is, it doesn't look like much, but it's your job to put 'charm' in it." A large order!

In considering external design in relation to the diverse products of our company, I should like to dispel any idea that attempt is made to elaborate, ornament or deliberately decorate any device unless there is excellent reason for doing so. Electrical and mechanical devices, which comprise the major part of our output and are created for some industrial application, seem to look best when they are of the simplest possible form or mass, while devices for domestic or public use are apparently best when given some degree of decorative treatment consistent with their intended environment.

The first of these groups presents much of interest in its own way, partly because of the fascination of studying the appropriate uses of various metals and materials, the processes for their fabrication, or the special application of the device being designed. In the second group, the household devices, come all the well-known things like refrigerators, ranges or the many handy devices for either the kitchen or laundry. A group of household appliances that requires a different treatment consists of implements for the dining room, such as those for preparing coffee, tea, waffles, toast, etc., while clocks, radio cabinets or the new thermal control for house heating find places in either dining room, library or reception hall and must be treated accordingly.

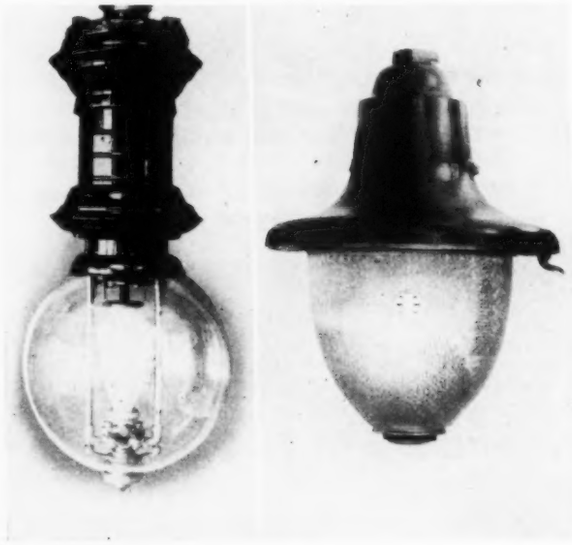
Lighting Effects

In the general group of electrical apparatus which I term for "public" use, and to separate the devices as design types distinct from all the industrial and small household articles, come exterior lighting either for expositions, buildings, streets or boulevards, spectacular lighting demonstrations or electrically operated and controlled fountains. This latter development has opened up a field with a lot of fun in it for the decorative designer, for with the perfected automatic electrically operated valves, heat-resisting glass of rich and desirable colors and the thyratron control for smoothness in the blending and changing of colors, fountains are being built from the small garden type with its accompanying tiles, pottery and planting, to the mammoth sculpture-embellished monument for a great park or public square. Added to these are the modern types of power stations and the recent advancement of the outdoor substation which has a unique architectural quality all its own.

When an average engineer is given a problem in the design of a device he naturally concentrates on mechanical design embracing efficiency, cost and a mass of matters that have small bearing on ultimate appearance, and as his education in architectural design is generally very sketchily treated in the schools for the training of the young in engineering, he gives little thought to the final appearance of the device until it is a working model. That may be as it should be, for few men have been gifted with both mechanical and artistic creative ability. Of course, there are many men who invariably produce designs that are superior in appearance, for herein enters that indefinable element of personal taste with which some men are naturally gifted and which is unconsciously reflected in their work.

During the last few years systematic efforts have been carried on by my department to assist the designing engineers toward a greater appreciation of the importance of appearance of apparatus by a series of lec-

How far we have come in thirty years. A lighting unit as the last generation designed it (left), as we design it today (right)



tures on the subject at the different factories, and by continued effort toward personal contact with the designing engineers while their creations were still in the developmental stage on the drafting board. This has proved a most interesting process, leading the decorative designer into the greatest variety of problems and the pleasantest associations with men highly trained and competent in their own work and who are showing a keener interest in the effort of trying to make things better looking. These contacts are mutually profitable for they lead one to a broader knowledge of the endless and absorbing details of processes and materials, which knowledge is quite essential for intelligent cooperation with the designing engineers.

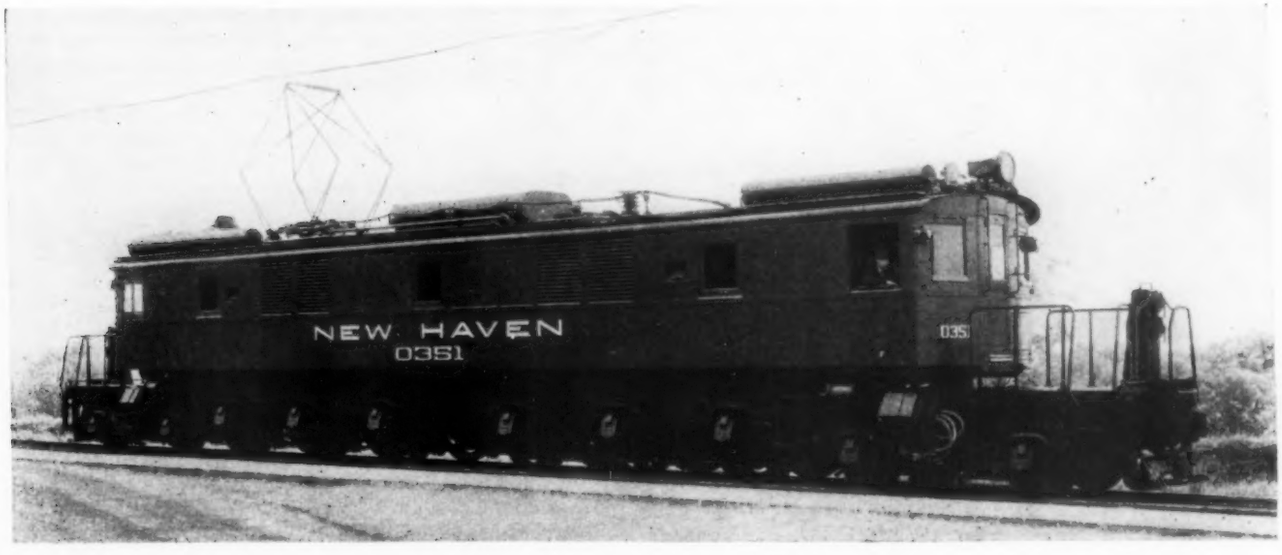
In the modern factory few mechanical devices are the work of any one mind, but pass through an evolutionary process that may be brought about by a variety of causes. Just so, the article that finally reaches the market may undergo a complete metamorphosis in the factory after the time of its conception by its inventor. Some of the latest apparatus for air conditioning might be used to illustrate this phase of the coordination of mechanical and aesthetic design. From the start of the first calculations through all its long developmental stages the keynote of the design was simplicity and harmonious proportions for both mechanical structure and external appearance.

Streamlined Locomotives

I think it was Bassett Jones who said that the modern office build[illegible] is a gigantic machine. The interior is certainly that while the exterior is slowly taking on that aspect for it is losing its treatment of encrusted ornament and moving little by little, in its external design, into the class of a machine of complete utility like an electric locomotive. The architecture of that machine has not been overlooked, for a study of the many types both here and abroad will show that much attention has been given to appearance. One hears talk of streamlined electric locomotives. The future may develop something of the sort, but it is the opinion of designing engineers that we are not at present ready for it. These machines are not submarine boats but run on rails, are of limited length and draw enormous loads, and it must be further realized that the interior is one solid mass of intricate machinery of which every ounce functions, and that all of the devices attached to the exterior are there for utility and accessibility. They may look somewhat complicated at first glance but their simplicity and tough mechanical structure is of the boiled down variety. A glance at the picture of the locomotive built for the N.Y.,N.H.&H. will show that the windows, ventilators, tanks, etc., are carefully spaced to give a general balanced effect, since this machine like most electric locomotives for train service has to travel equally well in two directions.

In speaking of outdoor illumination, I might say that most of these problems are of monumental character. Some of them are highly special and do not precisely come in the field of industrial design but become elements in an architectural scheme. They all do, in some form, utilize standardized parts somewhere in their makeup. An exception to this is the development of a group of designs for the lighting of outlying districts of cities composed of a series of interchangeable parts to meet varying practical conditions, which very much simplifies the problem of both the manufacturer and the lighting company which can carry in stock groups of these coordinated parts to be assembled to meet requirements. In this field the tendency to simplicity of form is exemplified by the two pictures, one of an arc lamp of thirty years ago and the other of the way the same lighting problem would be solved today.

I have observed that the majority of forms that mechanical things naturally take in order to function are readily adaptable to some decorative treatment and still agree with the essential conditions for modern shop production, but occasionally one encounters a device that seems to be like Cyrano or the Hunchback—just inherently homely, for it takes much effort to whip it into a form which, to use my engineer friend's expression, has "charm" in it.



Since an electric locomotive is designed to run equally well in either direction it can have no front or back and must present a balanced appearance

COMMUNICATION and COMMENT

Corrosion Resistance of Stainless-Clad Welded Sheets

W. J. WACHOWITZ
President, Alloy Products Corporation

When "stainless" steels were first introduced, considerable difficulty was encountered in attempting to weld the metal. Admittedly, there was much to be learned in the handling of this new metal and it was to be expected that there would be a number of failures in its application, particularly where welding was involved. In the course of time, improved welding rods, better welding control and better procedure were developed with the result that today there is no difficulty in welding the chrome-nickel steels.

It is but natural that with the introduction of the stainless-clad steels, the situation regarding the welding of such steels was at first quite similar to that which existed at the time of the introduction of the solid stainless sheets. Here again, with the perfection of the welding procedure the difficulties at first encountered have been eliminated entirely, although some engineers are still under the impression that from a corrosion-resisting standpoint, the weldability of the clad sheets is open to question.

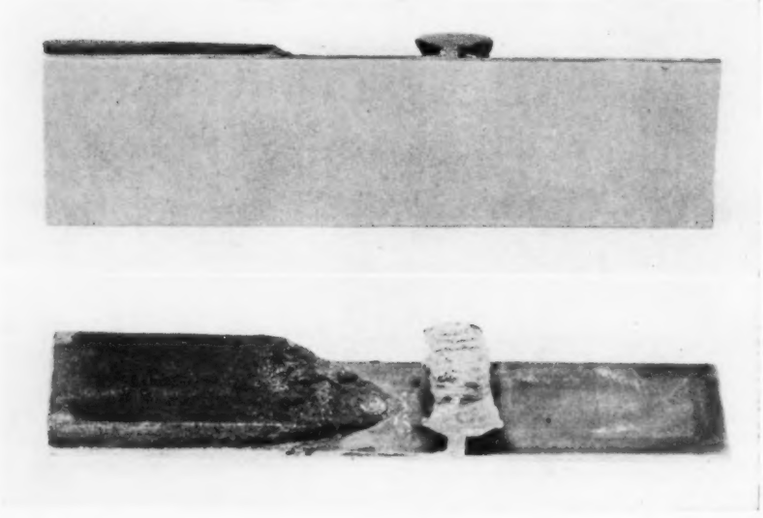
With reference to the corrosion resistance of welds made from stainless-clad sheets, the principal question hinges on whether any carbon steel could be dissolved in the weld of the stainless steel. Our company has done considerable research and development work on this very subject. Tests made subsequent to the development work have convinced us that with proper welding procedure, the carbon steel will not dissolve with the stainless steel during the welding process.

A striking proof of the above statement is shown by the results of a test, as illustrated in the accompanying photographs. Two pieces of stainless-clad were welded together and the piece was then boiled in concentrated nitric acid for approximately 76 hours at 185 deg. F. All of the mild steel adjacent to the weld was dissolved, but as can be seen from the photographs there was no visible effect whatsoever on the stainless part of the weld itself. This test is only one of many that we have conducted on various gages of such clad sheets.

One explanation of this corrosion resistance in and at the weld is that there is no precipitation in the weld metal because the mild steel absorbs the heat more rapidly than the solid stainless cladding. Therefore, there is a tendency for the stainless to anneal itself somewhat during the welding procedure.

Incidentally, we have also found that the stainless-clad steel is considerably easier to weld than the solid stainless sheet if the proper method is used. Other advantages of using the stainless-clad are that work strains do not develop as readily as they do with solid stainless steel because of the mild steel backing.

Although the carbon steel has been eaten away by acid, neither the weld metal nor the stainless cladding has been affected



Calculating Connecting Rod Clearance

W. W. JOHNSON
Cleveland, Ohio

In the design of reciprocating engines, compressors and pumps, the accurate determination of the clearance between the connecting rod and the cylinder wall is a difficult problem to solve by graphical methods. It was for this reason that the following analytical solution was developed. The same method can be used for calculation connecting rod clearances in other mechanisms.

When the design has developed to the stage where the clearance must be calculated, the length of the connecting rod, the crank-throw, the diameter of the cylinder, and the width of the connecting rod usually have been calculated previously. Assuming these conditions, the point of interference can be determined by using the equations given in the accompanying table.

First, the angle between the connecting rod and the cylinder axis is found by substituting in Equation (3), and solving by Horner's method. Second, the intersection of the cylinder wall and the connecting rod axis is located with reference to the crankshaft center from Equation (2). Third, Equa-

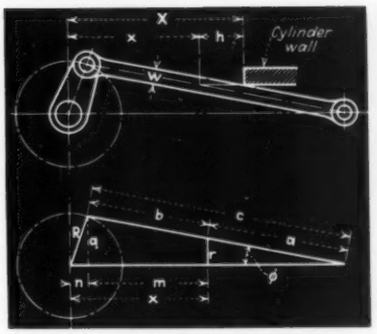
tion (1) is used to correct the result for the width of the connecting rod.

As an example, assume the following conditions have been determined in the design:

Length of connecting rod.... $c = 10$ in.
Crank-throw ..... $R = 2$ in.
Cylinder radius ..... $r = 1$ in.
Connecting rod width..... $w = \frac{1}{2}$ in.

Substituting the first three values in Equation (3), and solving by Horner's method, $\sin \phi = 0.1876$, and $\phi = 10$ deg., 48 min., 40 sec. Substituting this value of ϕ in Equation (2) gives $x = 5.28$ in. Then, using Equation (1), the distance from the crankshaft center to the interfering plane of the cylinder wall is found to be 6.61 in.

The development of the three equations used in this analytical method is outlined in the table.



$$X = x + h = x + \frac{w}{2 \sin \phi} \quad (1)$$

$$a = r \csc \phi; \quad b = c - r \csc \phi$$

$$m = b \cos \phi = (c - r \csc \phi) \cos \phi$$

$$q = c \sin \phi; \quad n = \sqrt{R^2 - c^2 \sin^2 \phi}$$

$$x = m + n = c \cos \phi - r \cot \phi + \sqrt{R^2 - c^2 \sin^2 \phi} \quad (2)$$

Differentiating, term by term and adding differentials:

$$\frac{dx}{d\phi} = r \csc^2 \phi - c \sin \phi - \frac{c^2 \sin \phi \cos \phi}{\sqrt{R^2 - c^2 \sin^2 \phi}}$$

Setting this derivative equal to zero, simplifying and writing in terms of $\sin \phi$:

$$c^2 (c^2 - R^2) \sin^6 \phi - 2 c^3 r \sin^5 \phi + 2 R^2 c r \sin^3 \phi + c^2 r^2 \sin^2 \phi - R^2 r^2 = 0 \quad (3)$$

Clearance between connecting rod and cylinder wall can be determined by these equations using the method given by Mr. Johnson

Preloading to Reduce Deflections

To the Editor:

In the design of a fixture to be used on a 50-ton press for determining the deflection of front axles for automobile trucks, the pressure-bar shown in the accompanying drawing was constructed. This fixture was used to span the two spring pads on the axle and to transmit the pressure from the ram of the press to the axle. Because of lack of space, two tension rods were used in the lower side of the pressure-bar to reduce the deflections of the pressure-bar under the 50-ton pressure. The tension rods were tightened up with an initial tension great enough to deflect the pressure-bar upward $\frac{1}{16}$ in. in the center. Cast iron was used for the pressure-bar, and the tie-rods were made of 40 carbon steel. What must be the initial tension in the tie-rods to obtain the $\frac{1}{16}$ in. deflection, and how much pressure is required to remove this $\frac{1}{16}$ in. deflection? —F. H. FREY

Cleveland, Ohio

Compressed Air to Avoid Foam

To the Editor:

Foaming of liquid often causes trouble such as described with reference to the soft drink vending machine in the June *Product Engineering* on p. 232. Sometimes it is a question of capacity; in other instances the presence of foam is inimical to good results. Foaming glue, for example, will give a poor bond. In dairies, it is much better if the milk can be handled in such a manner as to minimize foaming.

In the compressed air displacement method of handling liquids, agitation of the liquid and the production of foam is greatly reduced. In some factories using power glue-spreading machines, melted glue is forced by compressed air from the glue converters into the glue troughs on the spreaders. In the handling of milk some dairies have eliminated the pump as far as possible. When a truckload of milk comes to the plant, a milk line is connected to the bottom of the tank, and a compressed air line to the top. Pressure of the air in the tank forces the milk steadily and quietly through the line into a storage tank in the plant, entering the tank at the bottom and rising quietly. Where agitation or foam is undesirable, compressed air handling may be an improvement.

—JOHN E. HYLER

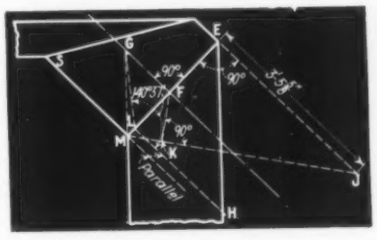
Peoria, Ill.

Calculating Dihedral Angles

To the Editor:

In the May *Product Engineering*, C. W. Lewis asked for a method of determining the dihedral angles of a hopper when the angle of opening was not 90 deg. The solution here illustrated uses the same method Mr. Lewis gave for the 90 deg. opening angles, and also illustrates a method to follow when the line GF does not cross the line of intersection of the surfaces.

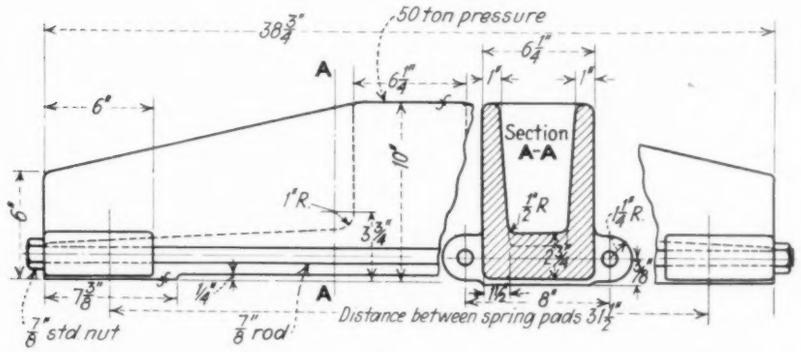
At any convenient point F on the line ME draw GF perpendicular to ME. Draw a line EJ perpendicular to ME, and make its length equal to the height of the hopper. Draw the line MJ and draw FK perpendicular to MJ.



The dihedral angle in the hopper problem can be found by using a method similar to the one Mr. Lewis gave

With F as a center and FK as a radius draw the arc KL. Draw the line GL and then draw LH parallel to MS. Note that if GF intersects MS then LH would be drawn to the point of intersection.

The angle GLH is the required in-



What are the stresses and deflections of this test fixture?

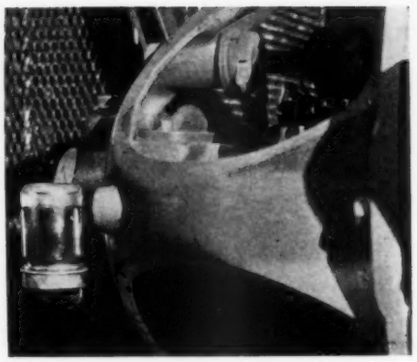
terior angle of the plane. Applying this method to the problem proposed by Mr. Lewis gives the interior angle *GLH* equal to 140 deg. 37 min.

—R. E. HUGHES
Detroit, Mich.

Remarkable Lubricating Record

A remarkable record for low oil consumption is reported by the Westinghouse Electric & Manufacturing Company concerning a motor installation. The accompanying picture shows the motor bearing with the oil feeder, the inverted glass of the feeder holding about 4 oz. of oil when full.

According to the report, no oil has been added to the bearing or the oil cup since the day the motor was installed, which was in June 1929. This motor, a 30-hp., 1,750-r.p.m., d.c. machine, has been running eight hours a



day every working day since it was put in operation.

A recent investigation of the motor shows that it is in good running order with no apparent reason why it should not continue to operate at the same low rate of oil consumption. The report does not state whether there are any unusual design features of the bearings which might account for this extremely low rate of oil consumption.

High-Speed Ratchet

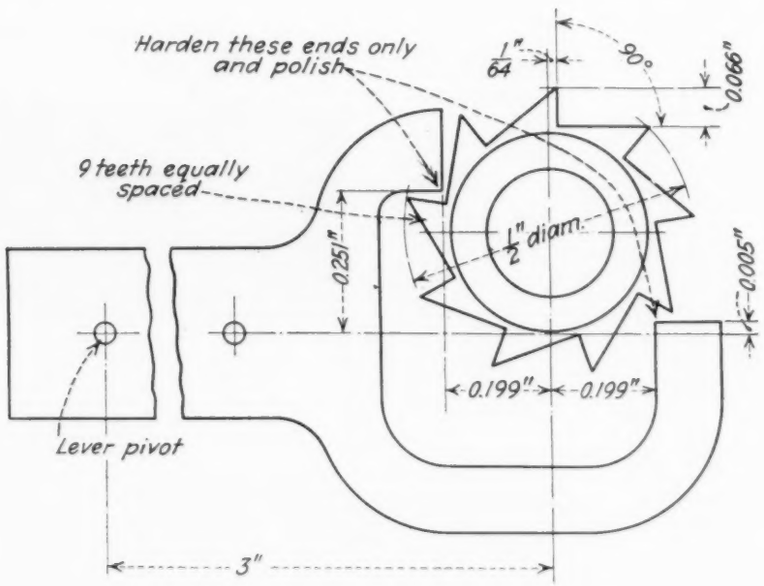
E. J. WHITE
Chatillon Telepoise Corporation

When used for high-speed counting, the rapid response of the photo-cell is of no advantage unless the counting mechanism is also designed for rapid operation. In an integrating weighing machine, impulses at a rate of 500 per minute were supplied by a photo-electric amplifier to a counter. In addition, the counter was required to be self-locking and capable of being used either as a drive or as an escapement. The mechanism finally developed had some unusual features.

The integrating weighing machine measured and totalized the quantity of material carried by a belt conveyor over a section supported on a scale platform. It was required to register the product of the weight of the material on the belt and the speed of the belt. Light directed on a photo-cell attached to the scale beam was interrupted by a slotted cylinder rotated in step with the moving conveyor belt, and vertical slots in the cylinder were of graduated length so that the number of light interruptions for one revolution of the cylinder varied with the position of the scale beam. Thus, the weight of the material on the scale section of the conveyor controlled the number of impulses while the speed of the conveyor belt governed the rate at which the impulses were transmitted. At high belt speeds, these interruptions were at a rate as high as 500 per minute.

After experiencing difficulties with several other types of escapements, the one illustrated here was developed. This escapement has no special angles, and can be machined completely with a 90-deg. milling cutter. It will be noted that the design requires a ratchet wheel with an odd number of teeth, and that one tooth passes for each complete cycle of operation. Also, the design is such that the power can be applied either to the escape wheel or to the escape lever.

The details given in the illustration are taken from the design incorporated in the weighing machine. In other applications, the details would probably be different, but this design can be used as a guide.



This high-speed ratchet can register as many as 500 impulses per minute

Chemical Finish for Die-Castings

To the Editor:

We are manufacturing items from zinc alloy die-castings to which it is desired to apply a black or brown chemical finish, not an enameled or lacquer finish. Can you furnish us with any information in regard to such a process, or give us the names of chemical firms who might be in a position to give us such information?

—C. F. S.

Considerable research work on this problem has been carried on by the New Jersey Zinc Company and it is reported that they are now in the process of developing an anodic treatment for zinc die-castings similar to the anodic treatment of aluminum. Perhaps other companies are working on this same problem, and it is possible that such a process has been perfected commercially. If any readers have knowledge of such a process, we would appreciate receiving such information for publication.

Laying Out Reverse Curves

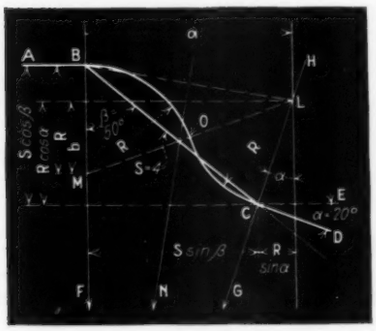
Two more solutions to the reverse curve problem given in the April number include the combined graphical and analytical method submitted by Mr. Hobart with his problem. We regret that space limitations will not permit publication of the many other contributions that were received in answer to this problem.

To the Editor:

A graphical method of determining the centers for the reverse curve in problems of this type is as follows: Draw line *BF* perpendicular to *AB* at *B* and line *GH* perpendicular to *CD* at *C*, intersecting at *N*. Bisect angle *BNH*. Draw a line perpendicular to the center line of angle *BNH* passing through *B*, which will intersect the line *GH* at *L*. *LC* and *BM* are the desired radii, and *L* and *M* their centers.

For the analytical solution, the problem for α, β and S, the radius of the two curves is found to be 1.971 in.

—Hans Schemm
New York, N. Y.



$$a = R \sin\alpha + S \sin\beta$$

$$b = R - S\cos\beta + R\cos\alpha$$

$$\overline{ML}^2 = 4R^2 = a^2 + b^2$$

Substituting for a^2 and b^2 and simplifying,

$$RS(\sin\alpha \sin\beta - \cos\alpha \cos\beta - \cos\beta - \cos\beta) + R^2(\cos\alpha - 1) + \tfrac{1}{2}S^2 = 0$$

Solving this equation for R,

$$R = \frac{S}{l}\left(\sqrt{k^2 + l} - k\right)$$

where $k = \cos(\alpha + \beta) + \cos\beta$

$l = 2(1 - \cos\alpha)$

Mr. Schemm's graphical and analytical solutions are developed for the general case

mathematical relations can be determined for the general case. The value of *R* can be expressed in terms of the angles α, β and the length of the line *BC*. In the accompanying table, this equation is developed from consideration of the right triangle having the hypothenuse *LM* and two sides *a* and *b*.

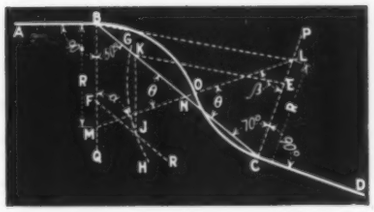
Substituting the values given in the

To the Editor:

For a graphical solution to the problem in reverse curves, draw *CP* and *BQ* perpendicular to *CD* and *AB*. On *CP* mark off some convenient distance *CE* and mark off the same distance *BF* on *BQ*. With *E* as a center and a radius equal to *2CE* draw arc *GH*. Draw *FR* parallel to *BC* and intersecting *GH* at *J*. Draw *JK* parallel to *BF* intersecting *BC* at *K*. Join *K* to *E*. Draw *BL* parallel to *KE* intersecting *CP* at *L*. Mark off *BM* on *BQ* equal to *LC*. Then *M* and *L* are the centers and *LC* and *BM* are the radii of the required arcs.

In the analytical solution given in the accompanying table, the angle θ is determined by the Law of Sines, thus fixing the angles α and β. Using the sine relations the length *BC* is found in terms of *R*, and the value of *R* is found to be 1.971 in.

—Dean E. Hobart
Ann Arbor, Mich.



$$MN = \frac{R \sin 50}{\sin\theta} \qquad NL = \frac{R \sin 70}{\sin\theta}$$

$$ML = 2R = \frac{R}{\sin\theta}(\sin 50 + \sin 70)$$

$$\text{or } \sin\theta = \tfrac{1}{2}(\sin 50 + \sin 70)$$

$$\theta = 58 \text{ deg., } 31 \text{ min., } 30 \text{ sec.,}$$

$$BN = \frac{R \sin\alpha}{\sin\theta} = 1.112R$$

$$NC = \frac{R \sin\beta}{\sin\theta} = 0.917R$$

$$BC = 2.029R = 4 \text{ in.}$$

$$R = 1.917 \text{ in.}$$

Mr. Hobart supplies an analytical and a graphical solution to his problem in reverse curves

DEFLECTIONS

NO MORE CIGAR BANDS?

Many attempts have been made to print the cigar band directly on the cellophane wrapper, but humidity and temperature cause the cellophane strip to shrink and stretch, resulting in unequal spacing of the "band" on the cellophane strip. A high-speed control that would automatically print the "band" in the right place was needed. The photo-cell did it.

•

CALLING MARS

Radio "beam casting" demonstrated by Westinghouse at the Century of Progress uses a wavelength of about 4 in., corresponding to a frequency of 3,300,000 cycles per sec. The radiations travel in straight lines, can be deflected or focused with polished metal surfaces and are not reflected by the Heaviside layer 200 mi. above the earth, making it possible to send the waves out into space.

•

KEEPING THE COLOR RIGHT

Poor lighting, cloudy weather, or near-sighted attendants have no effect on the uniform color of coffee roasted in the McCormick Electric Roaster because a Weston photo-electric cell decides when the color is right. Next in order would be to have the coffee percolated to uniform strength by photo-electric control.

•

LIGHT FROM A THERMOS BOTTLE

To maintain the temperature of the sodium vapor at 480 deg. F., a double-walled "thermos" globe is used for the sodium vapor lamps of the General Electric Company. As a result of the increased efficiency because of the decreased heat losses, a sodium vapor lamp using 80 to 90 watts gives as much light as a tungsten filament lamp consuming 215 watts.

•

A DRUM THAT'S HARD TO BEAT

At the Boulder Dam a permanent cableway, designed to carry weights up to 150 tons, requires two drums. Each drum is rolled from steel plates 2 in. thick, 42 ft. long, and 8 ft. wide, welded with General Electric equipment, and weighs 90,000 lb. Will be wound with more than a mile of cable.

· NEWS ·

Standard Designs of Motor-Speed Reducers

A discussion of several design problems in combining speed reducers and motors was included in a paper "Gearmotors," by R. S. Marthens, read at the annual meeting of the American Gear Manufacturers Association held May 4 at Wilkinsburg, Penna.

The use of standard capacities and standard output shaft speeds, and a combined nameplate for the unit were recommended. Rating charts and minimum standard motor speeds in relation to power factor were discussed. The paper includes a summary of the various types of gearing and the maximum ratios obtainable as standard manufactured units.

Typical designs for mounting and inclosing the gearing to take care of output torque and to provide for inspection and changing of gearing were illustrated. Attention was also called to the consideration of oil seals, oil level indicators, type of lubricants, and frequency of lubrication.

Circular "Slide Rule" Chart for Alloy Steels

An 8-in. diameter chart, printed in two colors on cardboard and of the "slide rule" type has been prepared by the International Nickel Company to show at a glance the various nickel alloy steels and the treatment required. The chart covers the nickel alloy steels in the range to provide a yield point between 55,000 and 155,000 lb. per sq.in., and also gives the corresponding tensile strength, Brinell hardness, elongation and reduction of area.

Perhaps the most valuable feature of this chart is the fact that it takes into consideration the mass effects in heat-treatment. The heat-treatments are given for sections ranging from 1 to 12 in. in diameter. To our knowledge, this is the first time that the factor of mass effects relative to heat-treatment has been set forth in such a specific manner.

Figures given on the chart represent typical values taken from an assembly of representative data obtained from numerous tests on nickel alloy steels ranging from 0.20 to 0.50 per cent carbon content. The form of the chart is such that it provides a convenient guide for the selection of steel for bars, shafts and forgings of simple shapes.

Copies of the chart can be obtained on application to the International Nickel Company, 67 Wall St., New York, N. Y.

New Copper-Lead Bearing Bronzes

Usually, the maximum lead content of commercial leaded bronzes prepared by the ordinary foundry methods is approximately 28 per cent. Bronze alloys containing 30 per cent or more lead must contain tin to prevent lead segregation and to strengthen the matrix of the alloy. Because of the possible unavailability of tin in times of war, the U.S. War Department has been particularly desirous for the development of a leaded bronze of high lead content, containing none of the so-called strategic metals, such as tin and antimony.

Under the sponsorship of the War Department, the Bureau of Standards has recently developed a series of copper-lead alloys containing 35 per cent lead, 0.4 per cent sulphur, 1.5 per cent silicon-zirconium alloy, and the remainder copper. Tests of this alloy indicated that it has properties equal to or superior to any of the commercial alloys tested, some of which contained as much as 6 per cent tin.

A detailed account of these researches together with the results of tests of bearings made of this alloy will be found in the May number of the *Bureau of Standards Journal of Research*.

Hysteresis in Spiral Springs

Hysteresis in spiral springs is a temporary effect evidenced by the failure of the spring to return exactly to the zero position after having been deflected for a long period of time, while aging is made evident in spiral springs by a slow permanent change in the zero position and calibration of the instrument over a long period of time. These two unstable effects found in the application of spiral springs were discussed by Robert W. Carson, formerly meter engineer with the Westinghouse Electric & Manufacturing Company, and now assistant editor of *Product Engineering*, in a paper presented before the American Institute of Electrical Engineers at Chicago.

The paper covers the manufacture of spiral springs, the effect of heat treatment on hereditary hysteresis, hardness tests, softening tests, effect of temperature and time on the forming of spiral springs, uncoiling tests and grid glow micrometer tests.

Six conclusions are drawn regarding the phosphor bronze spring materials. These are:

(1) Hereditary hysteresis is a minimum in spiral springs when the forming temperature is just below the softening point.

(2) The softening temperature range for cold worked phosphor bronze spring material is extremely critical and is lowered by an increase in the cold working of the material.

(3) The increase in diameter of the spiral spring as it is removed from the forming barrel indicates the relative intensity of the residual stresses in the spring.

(4) The tendency of the spiral spring to uncoil and increase in elastic modulus is a minimum under conditions which produce minimum residual stresses, while forming at a temperature just below the softening point produces the minimum aging tendency.

(5) The aging tendency of properly formed springs can be eliminated by low temperature heat treatment.

(6) Hereditary hysteresis is of a progressively continuous nature, and the creep rate is more rapid than the subsequent recovery rate.

This paper will be published in full in the Transactions of the A.I.E.E.

Tests on Large Steel Forgings Reported in Germany

A paper entitled "Contributions to the Knowledge of the Mechanical Properties of Very Large Forgings," recently presented before the Verein Deutscher Eisenhuttenleute and published in the March 2, 9 and 16 numbers of *Stahl und Eisen* contains a systematic and detailed study of the properties obtainable in exceptionally large forgings such as rotors, turbine runners and similar parts.

The steels studied were of the following approximate compositions: 0.2 carbon steel, 1.2 manganese steel, 2 per cent nickel steel, and a nickel-chromium-molybdenum steel containing 2.5-3 Ni, 1.5 Cr, and 0.5 Mo, approximately.

Detailed data are given on the conditions of production, heat-treatments

and mechanical tests. The results of exhaustive studies of the structure of the materials are also given.

Results of the tests are summarized in two sections, one relating to the individual steels, and the second section devoted to the comparison of the properties of the four types of material as influenced by the individual variables. This last section includes a tabular summary of the mechanical properties, impact strength of transverse and longitudinal test pieces from all classes of steel at varying stages of reduction.

Moving Picture Visualizing the Metal Industry

In cooperation with the Hupp Motor Car Corporation, the U.S. Bureau of Mines has prepared a new two-reel motion-picture film, "The Metals of a Motor Car." This is the latest addition to the Bureau's list of films visualizing the metal industry, and shows how metals and alloys are used in the design and construction of motor cars.

The scenario was written by J. M. Watson, metallurgist for the Hupp company and past president of the American Society for Steel Treating, and is based upon a paper presented by him before the Western Metal Congress in San Francisco early in 1931.

Loan of film for presentation before engineering societies and meetings can be had by addressing the U.S. Bureau of Mines, Pittsburgh Experimental Station, Pittsburgh, Pa., or the Museum of Mines Branch of the Museum of Natural History, New York, N. Y. The film can be obtained in either the 16 mm. or 35 mm. size.

Relative Value of Appearance Varies

Many articles have been published from time to time stressing the sales value of the appearance factor in more or less general terms. For what is perhaps the first time, an outstanding engineer has had the courage to make specific statements concerning the relative value of appearance as compared to the other essential factors in sales appeal.

In a paper presented at the Manufacturing Conference of the Case School of Applied Science, held at Cleveland on May 11, R. E. Hellmund, chief engineer of the Westinghouse Electric & Mfg. Co., quoted six items as being the principal ones essential in sales appeal.

In discussing the more technical products the author listed the items of sales appeal in the order of their importance as follows: (1) Serviceability and performance; (2) First cost; (3) Operating economics; (4) Reliability and expected life; (5) Convenience; (6) Appearance. As stated in the paper, convenience and appearance are listed last because with technical products their actual inherent value to the purchaser is usually less than that of the other features.

But in the case of less technical merchandising articles, particularly if they are of the semi-luxury type, the relative importance of the items entering into sales appeal may be entirely different. For this class of goods, Mr. Hellmund places appearance second only to serviceability and performance. Serviceability is given first place because every article, according to the author of the paper, except those of a purely artistic nature, must primarily render the service for which it is intended. In his paper, he also points out that the relative values of the various items will be altered even by the general business conditions. In times of depression, serviceability and performance relative to first cost will always be the dominating factors, while in all types of production equipment and machinery increased attention is paid to cost of operation as soon as business activities increase.

In his discussion, the speaker took up each of the six sales appeal items in detail, emphasizing their overlapping features. Of particular interest was his illustrations by actual example of the fact that machine members dimensioned on the basis of stress calculations and allowable stresses did not always result in a salable product.

MEETINGS

Society of Automotive Engineers—International Automotive Congress, Aug. 28—Sept. 4, Palmer House, Chicago, Ill. John A. C. Warner, general manager, 29 West 39th St., New York, N. Y.

National Metals Congress—Oct. 2-6, Detroit, Mich. W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio.

American Welding Society—Annual fall meeting, Oct. 2-6, Book-Cadillac Hotel, Detroit, Mich. Miss M. M. Kelly, secretary, 29 West 39th St., New York, N. Y.

EXHIBITIONS

Second American Exposition of Brewing Machinery, Materials and Products—Auditorium Hotel Chicago, Ill., Sept. 31 Oct. 1. J. R. Nicholson, 55 W. 42d St., New York, N. Y., secretary, Master Brewers Association.

National Metals Exposition—Oct. 2-6, Detroit, Mich. W. H. Eisenman, secretary, 7016 Euclid Ave., Cleveland, Ohio.

Tapered Roller Bearing Standards

At its annual meeting on January 25, 1933, the Standards Committee of the Society of Automotive Engineers formally adopted the new schedule for tapered roller bearing standards.

In view of this, a revised draft of Simplified Practice Recommendation R67, to be designated at R67-33, has been prepared by the Division of Simplified Practice of the Bureau of Standards. This revised draft brings the recommendations into accord with the S. A. E. Standard over the range of sizes to which the latter applies, the revision extending the scope of the original R67 recommendation to cover sizes up to 12 in. bore and certain steep angle bearings, not only for naval use but for general industrial use.

These revised recommendations are being transmitted to associations and individual producers, distributors and users for their acceptance. The revised schedule is to be effective one month after announcement by the Department of Commerce that the required degree of support has been recorded.

Training Inventors

According to Prof. G. M. Bartlett of Purdue University, the most important mental characteristics of successful inventors are originality and resourcefulness, imagination, observation and curiosity, perseverance and patience, intelligence and good judgment, ability to analyze, mechanical ability, self confidence and optimism, knowledge, memory and business ability.

In speaking before one of the sessions of the Society for the Promotion of Engineering Education at the annual meeting in Chicago on June 29, Professor Bartlett emphasized that both heredity and environment play an important part. One must be endowed with natural aptitudes but special training is required to develop inventive abilities. As the inventor of the future must have a good technical education it is logical to choose the engineering school for training them. It should not be difficult to place inventive type students in special classes where their originality can be encouraged.

NEW MATERIALS and PARTS

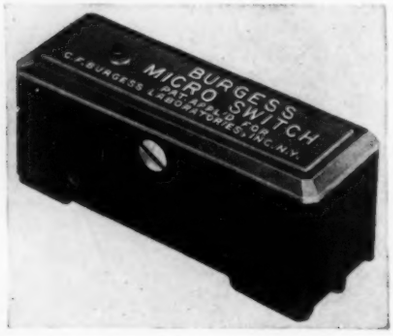
Smallest Stearns Magnetic Clutch

Is only 3 in. in diameter, 3 in. overall length, and weighs 3½ lb. As illustrated, the collector rings are mounted on the outside diameter, but can also be placed on a hub extension. A standard brushholder assembly is supplied.

Claimed that the clutch develops a torque of 40 in. lb. for continuous duty, requiring 15 watts d.c. Higher torque can be obtained for intermittent service. Where direct current of the proper voltage is not available, the clutch can be energized from a 110-volt a.c. circuit with a small rectifier designed for this application. Magnetic Manufacturing Co., Milwaukee, Wis.

Burgess Micro Switch

Is a compact, quick-acting switch requiring only 0.001-in. movement, and approximately 14-oz. pressure, a total of 0.004 in.-oz. energy. Rated at 10 amp., 110 volts; 5 amps., 220 volts, a.c. Black molded case is $1\frac{13}{16} \times \frac{13}{16} \times \frac{27}{32}$ in. Operating plunger protrudes through the top, terminals are on the bottom of the case. Said to be unaffected by vibration, suitable for use in any position. Beryllium copper contact springs are said to provide permanence, freedom from fatigue, absence of deformation, high-current capacity, high speed, ability to withstand high temperature. Available as a single-pole switch, normally closed, normally open, or double-throw, with silver-to-silver contacts. Applicable to thermostat control, limit switches, relays, control devices on automobiles, electric signs, railroad signaling systems, airplane controls. C. F. Burgess Laboratories, Inc., 202 E. 44th St., New York, N. Y.

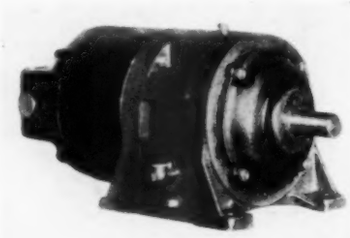


Impact Molding Material

Is a fibrous material processed with Bakelite resinoid said to have several times the shock resistance of ordinary molding material. Is similar to Bakelite laminated products, but differs in that it can be molded. Used for golf club heads, ledger covers, handles, knobs. Bakelite Corp., 247 Park Ave., New York, N. Y.

Small G.E. Gear-Motors

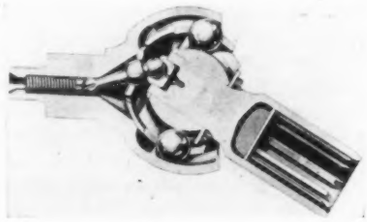
Available in two types in ratings from ⅛ to ¾ hp.: concentric shaft type, with speeds from 500 to 98 r.p.m., and the right angle shaft type, with speeds from 200 to 11 r.p.m. Planetary type of gearing is used with concentric shafts in the smaller ratios and worm gears singly or in combination with planetary type in the higher ratios. Textolite pinions, helical gears, quiet running worm gears operating in oil are said to keep noise to a low value. Removal of the cover plate provides access to the gear mechanism. Liberal oil capacity and a complete lubrication



are said to assure long life without frequent attention. Claimed that the full load horsepower and torque of the motor are developed at the output shaft. Unit is supported by feet on gear casing. General Electric Co., Schenectady, N. Y.

Rzeppa Universal Joint

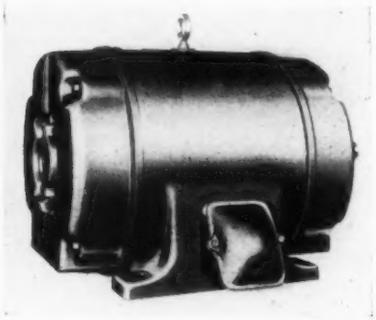
Designed to operate with constant angular velocity at any angularity up to 37½ deg. Especially designed for automobile propeller shaft, steering axles, live front and rear axles with independently sprung wheels, and for tractors, locomotives, power winches, tools. The two driving members, separated by a ball cage, have spherical contact surfaces. Six balls are placed in half grooves of the driving member and a piloting device controls their position. Designed so that the plane of the driving balls always bisects the angle between the connecting shafts. The rolling action of the driving balls is said to result in a high efficiency. No tools are required for assembling the parts. Available in two styles, high angle joint capable



of 37½ deg. angular displacement, and low angle joint designed for 15 deg.; sizes ranging from 1 in. to 2¼ in. nominal shaft diameters. All types are equipped with oil-tight covers. Gear Grinding Machine Co., Detroit, Mich.

Century Splash Proof Motors

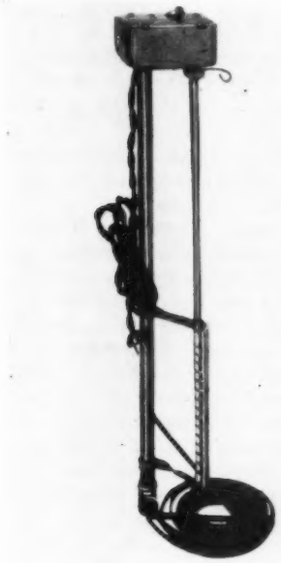
Are the same size as standard open frame motors. Recommended for use in dairies, packing houses, laundries, breweries, bottling plants; and for outdoor installations, such as pumps, cranes, conveyors, lift bridges, turn-



tables. One-way ventilation is provided by intake and outlet openings in the lower section of the cast iron end brackets. The bearing bracket is fitted to the frame by a sealed fit and cartridge type grease lubricated ball bearings are used. A four-way position terminal box is provided. Available in capacities from 1 to 30 hp. Century Electric Co., St. Louis, Mo.

Thermador Immersion Heater

For heating water, oil, or other liquids, has a built-in thermostat adjustable from 80 to 180 deg. F. Available in capacities up to 5,000 watts, 110 or 220 volts a.c. Special finishes can be furnished if desired for certain chemical compositions. Claimed to maintain temperature within plus or minus one deg. F. Thermador Electrical Mfg. Co., 116 Llewellyn St., Los Angeles, Calif.



Woodward Diesel Engine Governor

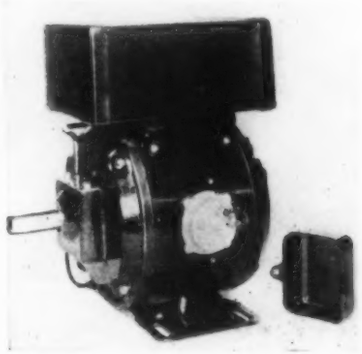
Consists of a control unit, power unit, and oil-pressure unit. The control unit includes a governor head, driven from the engine shaft; a compensating device that checks the power mechanism when the fuel supply to the engine has been changed; a load indicator, load limit, and speed droop adjustment. The power unit consists of a sleeve-type pilot valve, servomotor and mechanical linkage which forms a mechanical connection between the servomotor and the engine fuel control mechanism. The oil pressure unit consists of a rotary gear-type pump, positively driven from the engine shaft, and a spring-loaded relief valve. The pump operates continually and is completely immersed in oil. The spring-loaded relief valve maintains constant oil pressure, which is the force employed by the pilot valve to control the servomotor. Combining sensitive indication with positive control, this governor is said to respond to a speed change of less than 1/100 of 1 per cent; claimed that the governor is dead beat and operates without hunting for all values of speed droop and load, and does not require speed droop to prevent hunting. The governor is provided with a load indicator, an adjustable dial indicating load limit, a speed droop dial and a synchronizer; all are adjustable with the unit in operation. Woodward Governor Co., Rockford, Ill.

Packing for Yarway Seatless Blowoff Valves

Consists of several stainless steel rings with long fibre asbestos packing between them. Packing is compressed and heat-treated during assembly so that the ring is a complete unit, maintaining small clearance with the valve plunger. Claimed that this laminated packing eliminates blowdown leakage at pressures up to 2,100 lb. per sq.in., and under throttling service. Stated that the new packing has a life six times as great as packings previously supplied, and that wire-drawing is eliminated. Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

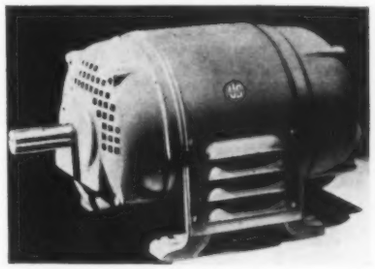
Westinghouse Capacitor Motor

For air-conditioners, refrigerators, oil burners; is protected from overheating by a disk-type thermostat mounted on the motor frame. Motor is supported on a pressed steel base by springs, with snubbers provided to limit oscillations when the motor is started. Claimed that a large oiling system, tested transfer switch, and whip-less motor shaft contribute to long service, and that electrical design and resilient spring mounting reduce noise. Stated that capacitor squirrel cage motors are more efficient than other types of single-phase motors, are free from commutator and brush troubles, have high starting torque with moderate starting current. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



U.S. Doublenclosed Motor

Has two inclosing frames with a fan mounted between them. The inner frame completely incloses the electrical windings, stator, rotor, anti-friction bearings and bearing chambers. The outer frame covers the whole unit.



Cooling air passing between the two frames, does not come in contact with the windings or rotating parts. Furnished with asbestos-protected electrical windings; rotor cage, bars and end rings die-cast of aluminum in one piece. All cast-iron parts are normalized. Bearings are grease packed and sealed within a labyrinth chamber. Claimed that lubrication is required but once a year. Motor also available in an explosion-proof design in which the bearing support has an extra long sleeve bushing of self-lubricating graphite bronze, and the end bracket supports, end bells and outer bearing housings are made of alloy steel instead of cast iron. A sealed terminal chamber is used which is said to be waterproof, acidproof and alkali-proof. U.S. Electrical Manufacturing Co., Los Angeles, Calif.

Cutler-Hammer Limit Switch

Is a rotating-cam limit switch for use on steel-mill equipment such as automatic feeder-catcher table control systems and tilt-table drives. Split cams are arranged in pairs to give any adjustment between 4 and 8 deg. on the shortest cam, between 180 and 360 deg. on the longest cam. Designed so that any cam can be adjusted without disturbing others, and only a screw driver and hammer are needed to make adjustments. Cams are of steel, 6 in. in diameter. Claimed that the position of the contacts is determined only by the position of the camshaft, making it impossible to disarrange the operating sequence. Large bearing plates opposite the driving end permit removal of the entire cylinder and pinion without dismantling. Other

features are ball bearing camshaft, self-lubricated bearings on the cam levers, twin break silver-to-silver contacts eliminating pigtails. Available in standard and weather-proof inclosures. Cutler-Hammer, Inc., Milwaukee, Wis.

PX Fabrikoid

Is a lacquered fabric with the appearance and feel of cloth, can be worked like cloth, and can take the colors and designs of cloth, while at the same time has the durable, moisture-proof, washable qualities of lacquered material. Said to have resistance to wear and tear equal to the finest qualities of lacquered fabrics. Because of its durability, it is said to be especially suitable for binding for school and library books. Is available at prices which equal those of cloth, and in a variety of finishes ranging from textures which are rough and rugged to those which are as soft as silk. E. I. du Pont de Nemours & Co., Wilmington, Del.

Catalin

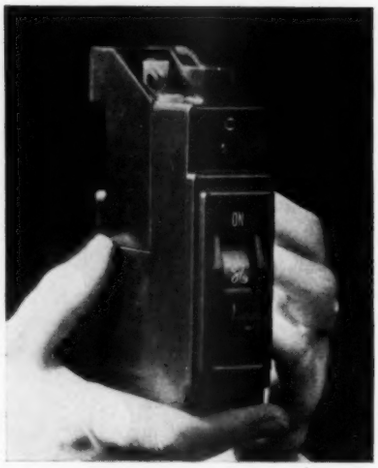
Is a cast synthetic resin of the phenol formaldehyde type, poured in liquid form into lead molds, and cured. Available in the form of rods, sheets, tubes, or special castings. Material is claimed to be non-inflammable, acid-resisting; suitable for handles, knobs, instrument and clock cases, trim for electrical appliances. Available in colors from clear crystal and white to jet black, in pastel shades, either plain or mottled. New colors can be made on short notice. Supplier states that mold charges run from 1/5 to 1/10 of those for molding powder, and the material machines and handles very similar to soft brass or hard wood. American Catalin Corp., 230 Park Avenue, New York, N. Y.

Castordag and Glydag

Two new colloidal-graphited lubricants are now available. Castordag, with a castor oil base is for use at high temperatures and heavy pressures; glydag is a glycerin base lubricant for low temperature service. Acheson Oildag Co., 654 Madison Ave., New York, N. Y.

General Electric AF-1 Breakers

Available in a complete line of small circuit breakers, rated up to 600 volts and 600 amp., designed for the control and protection of industrial circuits, house service entrance, branch circuits, refrigerators, ranges. On an overload the circuit is interrupted within a closed metal chamber. The



arc, drawn between the contacts, generates a pressure, increasing the resistance of the arc path, rapidly interrupting the circuit. Breaker cannot be tripped from the operating handle nor held in the closed position when an overload exists. The time lag is inversely proportional to the overload current. A Textolite housing provides convenient mounting in panelboards, distribution boxes. General Electric Co., Schenectady, N. Y.

Nuodex Lead Drier

A 16 per cent lead naphthenate-drier is now available in a non-staining water-white grade for use in the production of pure white paint, enamel and synthetics. Nuodex Products, Inc., 488 Frelinghuysen Ave., Newark, N. J.

Allis Small Diameter Motors

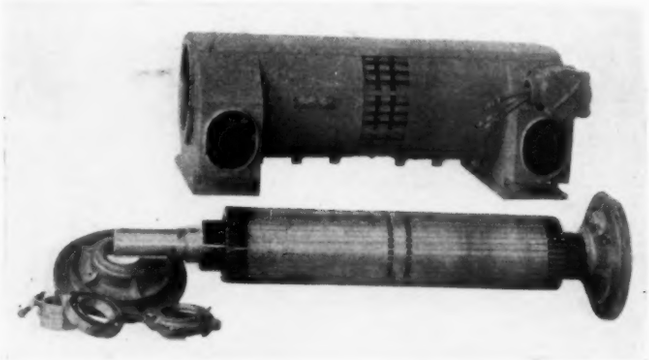
Are high powered motors for direct mounted grinding wheels, saws and cutterheads, where the diameter must be held to a minimum. The top of the motor is flat and for all capacities is only 5 1/16 in. above the center of the shaft. The motor diameter varies from 12 to 14 in.; the length varies according to the motor rating. The 100-hp. motor illustrated is approximately 40 in. long. Available in a self-ventilated design in ratings from 30 to 60 hp. Ratings from 75 to 100 hp. require a separate blower unit. Motors are rated at 1,800 r.p.m., 60 cycles, and can be wound for 220, 440 or 550 volts. The Louis Allis Co., Milwaukee, Wis.

Boker Nickel-Clad Steel

Available in sheets, hot-rolled, annealed and pickled, from No. 16 U.S.S. gage up to and including heavy plate sizes, and cold-rolled sheets and strips with bright and polished surface, as thin as No. 32 U.S.S. gage. Sheets are made by hot welding a slab of pure nickel to a steel base under high pressures at high temperature. Sheets can be supplied with nickel on one or both sides, and wire is also available with various thicknesses of nickel "cladding." Rolled nickel surface is said to be suitable for chromium plating. H. Boker & Co., Inc., 103 Duane St., New York, N. Y.

Type A Safety Switch

Designed for mill service is of compact construction—overall dimensions of 9x17½x4 in. for the 60-amp., 3-pole, 250-volt size. Switches incorporate such features as semi-floating, double-break V-blades, claimed to insure proper alignment and to keep contact surfaces clean. Stationary V-contacts backed up with steel springs, insure full contact under pressure. Individual barriers of arc-resisting asbestos are used. All actuating parts are case-hardened, and all steel parts of the mechanism are cadmium - plated. Switch can be removed to allow all the space in the box for pulling in wires. Claimed that removal of the switch as a unit facilitates quick inspection, easy replacement of parts, or substitution of a new switch, and that injury to or buckling of the metal in the back of the box when installed on an uneven surface will not cause misalignment of the switch unit. Fuse door is interlocked so that switch is tripped when the door is raised, and the switch cannot be operated with the fuse door open. Available in three lines, 250



volt d.c., 575 volt a.c., non-fusible type; 250 volt a.c. or d.c., fusible; 575 volt a.c., fusible. The Electric Controller & Mfg. Co., 2696 E. 79th St., Cleveland, Ohio.

Trent Heating Units

Are electrical-resistance heaters designed to develop even heating over the active length of the heater, or concentrated heat at certain positions along the length if required. The heating element is nickel-chromium supported in molded insulators, locating the element with respect to the casing. Intervening spaces are filled with refractory insulating powder. Casings are flat metallic tubes with the ends pressed tight and sealed. Ratings can be changed or heat concentration modified at the factory using the old casing and terminal. Available in two designs, for 750 deg. F., and 1,400 deg. F., maximum temperatures. Harold E. Trent Co., 618 N. 54th St, Philadelphia, Pa.

DeLaval Double Reduction Worm Gears

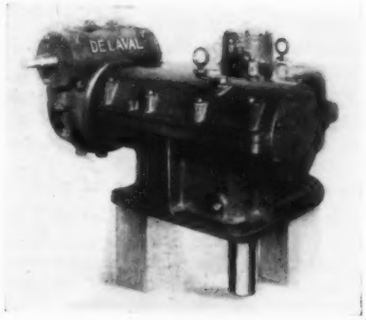
Use separate housings for the high-speed and slow-speed gear. The unit with the horizontal slow-speed shaft can have the high-speed driving shaft extended in either or both directions, and the slow-speed shaft likewise. The unit with the vertical slow-speed shaft can be combined in six ways. The worm may be rotated either clockwise or counter-clockwise. Gear and worm teeth, and bearings are lubricated by splash system, the high-speed gear wheel and the slow-speed worm dipping in an oil bath in the casing. Ball bearings are used throughout except on the slow-speed shaft, which has sleeve bearings, although tapered roller bearings are available for units in which the slow-speed shaft is horizontal. Standard gear-ratios are from 80 to 1 up to about 5,000 to 1, and higher ratios can be obtained if required. Torque capacities are from 4,500 ft.-lb. to 220,000 ft.-lb. DeLaval Steam Turbine Co., Trenton, N. J.

Scovill "Y" Lacquer

For use on vanity cases, lipstick containers, perfume bottle caps, cream jar closures, silverware, beverage shakers, ash trays, buttons, ornaments. Is said to be odorless, colorless, transparent, not subject to age darkening, and unaffected by perspiration, alcohol, essential oils, and acetone. Is also a suitable vehicle for use with aniline dyes to obtain transparent color effects, and for use with pigments to produce pastel shades and deep colors. Claimed that it can be mixed with existing lacquers and enamels, imparting to them some of its characteristics. Can be applied by spraying, dipping or rolling. It is not air dried but obtains its properties when polymerized at a moderate temperature. Said to be particularly adapted to silver-finished products. Scovill Manufacturing Co., Waterbury, Conn.

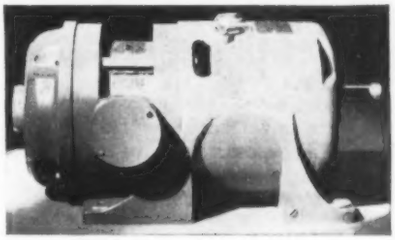
Large Wedgbelt Pulleys

Completes the line of pressed steel pulleys using the hub and arm construction, with the steel grooves mounted upon the pulley face. This construction is claimed to provide true running with greater power efficiency and longer belt life. American Pulley Co., Philadelphia, Pa.



Reliance Type S Gearmotors

Combining motor and speed reducer into one compact, self-contained, protected unit, with speed reductions from 6:1 to 40:1. A cartridge-type gear unit carries all gears and bearings except the high-speed pinion and bearing. The cartridge can be removed readily without disturbing the alignment of gears or motor bearings, and the ratio can be changed by the user by changing the high-speed pinion and gear. Rotating the cartridge gear unit provides 4 to 8 positions of the output shaft. Gears are cut with helical teeth of full involute form, and roller and ball bearings are used throughout. Oil height is checked by a bayonet-type oil gage. Feet cast integral with the gear housing provide a solid support. Available in sizes rated from $\frac{3}{4}$ hp. and up, furnished with both a.c. and d.c. motors of various types. Multi-speed and adjustable speed motors can be supplied, as well as special right angle and vertical drives. Reliance Electric & Engineering Co., 1042-1090 Ivanhoe Road, Cleveland, Ohio.

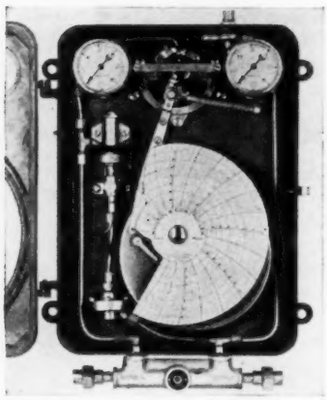


Dissteel

For use in thin planer knives; claimed to have better edge-holding qualities and to be sharpened more easily than high-speed steel. Planer knives made from this material are said to give two to four times the service of high-speed steel knives. Henry Disston & Sons, Inc., Philadelphia, Pa.

Bristol Controllers

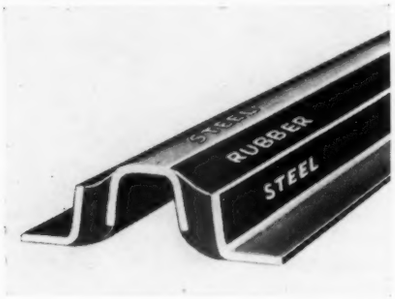
For controlling temperature or pressure at a predetermined rate. Available for any range of temperature from —40 to 1,000 deg. F., or pressures from 10 to 2,000 lb. per sq.in. Controlling cam is prepared from a graduated chart on sheet aluminum, and is cut by the user to give the desired control. Cam is driven by an electric or spring clock. Air supply and control



gages are self-contained, and controller is inclosed in a moisture-proof aluminum case. The controller is also available in a model equipped with an indicating pointer showing instantaneous pressure or temperature. Pointer is unrestricted by the control. The Bristol Co., Waterbury, Conn.

Firestone Vibration Dampeners

Cushion strips of tough, live rubber are bonded to plates of brass-plated steel, with an adhesion said to be greater than 250 lb. per sq.in. A section of the rubber-metal cushion is bolted to the machine and then to the floor, leaving the rubber strips in shear between the two plates. The lower curved contour of the rubber cushion is designed so as to come in contact with the base progressively for building up resistance to heavy loads and



shocks by placing the rubber under compression. The rubber used is said to be a high tensile, long life compound, and is available in three densities or hardnesses of rubber compound. Supplied in three standard lengths: 12 in., 24 in., and 36 in., from which short lengths can be cut off with a hacksaw. Firestone Tire & Rubber Co., Akron, Ohio.

BULLETINS and PUBLICATIONS

Research Bulletins

Mellon Institute of Industrial Research, Pittsburgh, Pa. "The Activities of Mellon Institute During 1932-33." Through the present economic crisis, industrial research at the Mellon Institute has been continued on the following projects: air pollution, new building materials, coke and coal gas, food varieties, merchandise research, organic synthesis, packaging, petroleum, shoe leather, new uses for sugar. A 12-page bulletin reports on progress made in the above subjects, and in addition reports on their financial condition, and the progress on the new building.

▼

Ball Bearings—New Departure Mfg. Co., Bristol, Conn. Sheet No. 202 FE, "Radial Vane Type Hydraulic Pump," showing application of ball bearings.

Blowers—Connersville Blower Co., Inc., Connersville, Ind., 2-page bulletin 21-B24, "Rapid and Sanitary Transfer of Liquids."

Brake Lining—The Asbestos Brake Lining Association, Inc., announces the 1933 edition of "Automotive Data Book," listing sizes and prices of brake lining and clutch facing, available from members of the Association.

Catalin—American Catalin Corp., 230 Park Ave., New York, N. Y., 4-page leaflet, "The Gem of Modern Industry," including physical properties, weights, working methods for cast phenolic resin. Also small 16-page booklet, "Catalin," with a sample product, listing uses and sizes.

Chromium Seamless Pipe—National Tube Co., Pittsburgh, Pa. Illustrated 16-page bulletin No. 20, "4-6 per cent Chromium Seamless Pipe and Tubes," listing advantages, applications, high-temperature properties, stability, corrosion-resistance, and standard sizes.

Electric Heaters—Harold E. Trent Co., 618-640 North 54th Street, Philadelphia, Pa., 4-page leaflet, "Trent Electric Heating Elements and Units," construction, application and catalog information.

Electric Motor—U. S. Electrical Mfg. Co., Los Angeles, Calif., 4-page leaflet, "U. S. Doublenclosed Motor," construction details and application of enclosed and explosion-proof motors.

Flashers—Reynolds Electric Co., 2650 W. Congress St., Chicago, Ill., 4-page bulletin No. 54, "Thermostatic Flashers," technical, catalog information.

Gear Motor—Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio, 4-page bulletin No. 400, "Type S Reliance Gearmotors," details of construction, well illustrated.

Governor—Woodward Governor Co., Rockford, Ill., 4-page technical bulletin, "Woodward Diesel Engine Governor," operation and performance.

Linestarters—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., 2-page leaflet, "Class 11-204 Combination Linestarters" includes details of construction and application.

Stainless Steel—American Sheet & Tin Plate Co., Frick Bldg., Pittsburgh, Pa. Attractively-illustrated, 24-page booklet, "American U.S.S. Stainless & Heat-Resisting Steel Sheets." Types and selection of alloys; fabrication, analysis, physical properties and uses.

Stainless Steels—Allegheny Steel Co., Brackenridge, Pa., offers the following series of technical data sheets giving composition, corrosion resistance, physical properties, data, uses:

Bulletin A-1, "Allegheny Metal Controls Corrosion."
Bulletin S-33, "Allegheny—33."
Bulletin S-44, "Allegheny—44."
Bulletin S-46, "Allegheny—46."
Bulletin S-55, "Allegheny—55."
Bulletin S-66, "Allegheny—66."

Also, a 12-page circular "Fabrication of Allegheny Stainless Steels," with data for all types; an 8-page bulletin, A-10, "Allegheny Metal Controls Corrosion," illustrates uses and applications; a 28-page bulletin, A-11, "Allegheny Alloys, Standard Classification of Extras," giving prices.

Tin—The International Tin Research & Development Council, Manfield House, 378 Strand, London, W.C. 2, has prepared a 138-page booklet, "Tin—World Statistics for 1933." Contains useful tables on prices, production, consumption, stocks, supplies and consuming industries. A foreword recounts the effect of the depression on the tin industry. Copies are available from L. J. Tavener, U. S. Representative, 149 Broadway, New York, N. Y.

Transformers—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., 2-page leaflet, "Type MT Small Transformers," for bell ringing, furnace control, signaling.

Valve Disks—Crane Co., Chicago, Ill. Reference Sheet, "Plug Disk Brass Valves."

Vibration Dampeners—Firestone Tire & Rubber Co., Akron, Ohio, 2-page circular on the applications of Firestone rubber vibration dampeners.

Welding Fittings—Crane Co., Chicago, Ill. 4-page circular, "Crane Reference Sheet on Welding Fittings."

Zinc Die Castings—New Jersey Zinc Co., 160 Front St., New York, N. Y., 18-page booklet, "The Plating of Rolled Zinc and Zinc Die Castings," includes information on polishing, cleaning, plating with various finishes, and tests.

Tables for Calculating Helical Type Springs

Contributed by W. M. Griffith
Executive Engineer, Atlas Imperial Diesel Engine Company

Tables on this and the following page are a part of the article "Engineering Standards for the Design of Springs," appearing on pp. 242-246 of this issue. On p. 246 will be found the table for music wire sizes. All formulas and data required for the design of helical springs for tension, compression or torsion will be found in the above mentioned article and the tables given here.

In the tables of wire sizes are given the square, cube and fourth powers of the wire diameter, thereby relieving the designer of making these time consuming calculations and avoiding the possibility of errors.

Maximum permissible stresses as set forth in the two tables below are based on the results of spring performance over a period of years. Care must be exercised in determining which of the three classes of service apply, and in case of doubt the lower stress values should be used. Although the permissible working stresses as given here may appear to be too conservative, experience has proved that the use of higher working stresses usually results in springs that do not give satisfactory service.

Steel Wire Sizes

(Washburn & Moen Gage)

No.	Decimal	d^2	d^3	d^4
9/16	0.5625	0.3164	0.17798	0.10011
17/32	0.5313	0.2822	0.14993	0.07965
1/2	0.5000	0.2500	0.12500	0.06250
7—0	0.4900	0.2401	0.11765	0.05765
15/32	0.4688	0.2197	0.10300	0.04828
6—0	0.4615	0.2130	0.09829	0.04536
7/16	0.4375	0.19141	0.08374	0.03664
5—0	0.4305	0.18533	0.07978	0.03435
13/32	0.4063	0.16504	0.06705	0.02724
4—0	0.3938	0.15508	0.06107	0.02405
3/8	0.3750	0.14063	0.05273	0.019775
3—0	0.3625	0.13141	0.04763	0.017268
11/32	0.3438	0.11816	0.04062	0.013963
2—0	0.3310	0.10956	0.03626	0.012004
5/16	0.3125	0.09766	0.03052	0.009537
0	0.3065	0.09394	0.02879	0.008825
1	0.2830	0.08009	0.02267	0.006414
9/32	0.2813	0.07910	0.02225	0.006257
2	0.2625	0.06891	0.018088	0.004748
1/4	0.2500	0.06250	0.015625	0.003906
3	0.2437	0.05939	0.014473	0.003527
4	0.2253	0.05076	0.011436	0.002577
7/32	0.2188	0.04785	0.010468	0.002290
5	0.2070	0.04285	0.008870	0.0018360
6	0.1920	0.03686	0.007078	0.0013590
3/16	0.1875	0.03516	0.006592	0.0012360
7	0.1770	0.03133	0.005545	0.0009815
8	0.1620	0.02624	0.004252	0.0006887
5/32	0.1563	0.02441	0.003815	0.0005960
9	0.1483	0.02199	0.003262	0.0004837
10	0.1350	0.01823	0.002460	0.0003322
1/8	0.1250	0.01563	0.001953	0.0002441
11	0.1205	0.01452	0.001750	0.0002108
12	0.1055	0.01113	0.001174	0.0001239
3/32	0.0938	0.00879	0.000824	0.0000773
1/16	0.0625	0.00391	0.000244	0.0000153
1/32	0.0313	0.00098	0.000031	0.0000010

Monel Metal, Phosphor Bronze and Brass Wire Sizes

(Brown & Sharpe Gage)

No.	Decimal	d^2	d^3	d^4
6—0	0.5800	0.3364	0.19511	0.11316
5—0	0.5165	0.2668	0.13779	0.07117
4—0	0.4600	0.2116	0.09734	0.04477
3—0	0.4096	0.16777	0.06872	0.02815
2—0	0.3648	0.13305	0.04855	0.017710
0	0.3249	0.10556	0.03430	0.011143
1	0.2893	0.08369	0.02421	0.007005
2	0.2576	0.06636	0.017094	0.004403
3	0.2294	0.05262	0.012072	0.002769
4	0.2043	0.04174	0.008527	0.0017421
5	0.1819	0.03309	0.006019	0.0010948
6	0.1620	0.02624	0.004251	0.0006887
7	0.1443	0.02082	0.003005	0.0004336
8	0.1285	0.016512	0.002122	0.0002727
9	0.1144	0.013087	0.0014972	0.00017128
10	0.1019	0.010384	0.0010581	0.00010782
11	0.0907	0.008226	0.0007461	0.00006768
12	0.0808	0.006528	0.0005275	0.00004262
13	0.0720	0.005184	0.0003732	0.00002687
14	0.0641	0.004109	0.0002634	0.000016882
15	0.0571	0.003260	0.00018617	0.000010630
16	0.0508	0.002581	0.00013110	0.000006660
17	0.0453	0.002052	0.00009296	0.000004211
18	0.0403	0.0016241	0.00006545	0.000002638
19	0.0359	0.0012888	0.00004627	0.000001661
20	0.0320	0.0010240	0.00003277	0.0000010486
21	0.0285	0.0008122	0.00002315	0.0000006597
22	0.0253	0.0006401	0.000016194	0.0000004097
23	0.0226	0.0005108	0.000011543	0.0000002609
24	0.0201	0.0004040	0.000008121	0.00000016322
25	0.0179	0.0003204	0.000005735	0.00000010266
26	0.0159	0.0002528	0.000004020	0.00000006391
27	0.0142	0.0002016	0.000002863	0.00000004066
28	0.0126	0.0001588	0.000002000	0.00000002520
29	0.0113	0.0001277	0.000001443	0.00000001631
30	0.0100	0.0001000	0.000001000	0.00000001000

PRODUCT ENGINEERING © REFERENCE BOOK SHEET

Tables for Calculating Helical Type Springs

Classification of Springs According to Service

Class	Deflection Cycles	Stress Range Per Cycle	Service
1	Rapid Regular	Uniform from zero to maximum or intermediate to maximum.	Valves Plungers, etc.
2	Rapid Irregular	Variable from zero to intermediate, intermediate to maximum, or zero to maximum.	Governors and Similar Service
3	Infrequent Irregular	Variable from zero to intermediate, intermediate to maximum, or zero to maximum. Maximum (static)	Relief Valves Static Loads

Maximum Permissible Stresses

Material	CARBON STEEL			VANADIUM STEEL			MUSIC WIRE		
Gage	Washburn & Moen			Washburn & Moen			Roebling Music Wire		
Modulus G	11,500,000			11,500,000			11,500,000		
Modulus E	30,000,000			30,000,000			30,800,000		
Class	**Size**	**Comp.**	**Exten.**	**Torsion**	**Comp.**	**Exten.**	**Torsion**	**Comp.**	**Exten.**	**Torsion**
1	0.5625 to 0.2437	—	—	—	48,000	38,400	57,600	—	—	—
	0.2253 to 0.1055	—	—	—	54,000	43,200	64,800	—	—	—
	0.105 to 0.0085	—	—	—	60,000	48,000	72,000	60,000	48,000	72,000
2	0.5625 to 0.2437	50,000	40,000	60,000	60,000	48,000	72,000	—	—	—
	0.2253 to 0.1055	56,250	45,000	67,500	67,500	54,000	81,000	—	—	—
	0.105 to 0.0085	62,500	50,000	75,000	75,000	60,000	90,000	75,000	60,000	90,000
3	0.5625 to 0.2437	60,000	48,000	72,000	72,000	57,600	86,400	—	—	—
	0.2253 to 0.1055	67,500	54,000	81,000	81,000	64,800	97,200	—	—	—
	0.105 to 0.0085	75,000	60,000	90,000	90,000	72,000	108,000	90,000	72,000	108,000

Maximum Permissible Stresses

Material	PHOSPHOR BRONZE			BRASS			MONEL METAL		
Gage	Brown & Sharpe			Brown & Sharpe			Brown & Sharpe		
Modulus G	6,000,000			4,500,000			9,250,000		
Modulus E	16,000,000			12,000,000			23,000,000		
Class	**Size**	**Comp.**	**Exten.**	**Torsion**	**Comp.**	**Exten.**	**Torsion**	**Comp.**	**Exten.**	**Torsion**
1	0.5800 to 0.2576	20,000	16,000	24,000	—	—	—	—	—	—
	0.2294 to 0.1019	22,500	18,000	27,000	—	—	—	—	—	—
	0.0907 to 0.0100	25,000	20,000	30,000	—	—	—	—	—	—
2	0.5800 to 0.2576	25,000	20,000	30,000	18,750	15,000	22,500	25,000	20,000	30,000
	0.2294 to 0.1019	28,125	22,500	33,750	21,100	16,880	25,320	28,125	22,500	33,750
	0.0907 to 0.0100	31,250	25,000	37,500	23,450	18,760	28,140	31,250	25,000	37,500
3	0.5800 to 0.2576	30,000	24,000	36,000	22,500	18,000	27,000	30,000	24,000	36,000
	0.2294 to 0.1019	33,750	27,000	40,500	25,310	20,250	30,375	33,750	27,000	40,500
	0.0907 to 0.0100	37,500	30,000	45,000	28,120	22,500	33,750	37,500	30,000	45,000